GENERALISATION OF SELF CONTROL FROM A FADING PROCEDURE IN A MULTIPLE CONCURRENT SCHEDULE

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ABSTRACT

Self control is an issue which is central to everyday life and the choices we make. From an operant behavioural perspective, self control can be described as choosing a larger more delayed reinforcer instead of a smaller more immediate reinforcer. Experiment 1 replicated a fading procedure in a single concurrent chain, with the subjects performing fewer sessions at each delay step than usual. No significant increases in self control were found, however graphs of the log response ratios conformed to the pattern which is typically found in a fading procedure. Experiment 2 involved the manipulation of several variables which are thought to influence self control. This was done in order to make responding more impulsive so that a fading proedure could be carried out in one of two concurrent chains which alternated in a multiple schedule. Increased deprivation and performing each component separately led to the largest increases in self control. In Experiment 3 a fading procedure was performed in one concurrent chain, whilst the other concurrent chain (with which it alternated) remained as a choice between a smaller earlier and a larger later reinforcer. Again, no significant increases in self control occurred as a result of the fading procedure. However, unlike in Experiment 1, no response pattern typical of a fading procedure was found. In the non-fading component, it was expected that more choices of the large reinforcer would be made when the subjects learned to be more self controlled (as sensitivity to delay decreased and large reinforcer choices increased). A conclusion could not be made regarding this issue. The literature suggests that self control does not generalize to other behaviours as easily as previously assumed. In future research it would be beneficial to examine the limits of generalization and to investigate the conditions which will facilitate the generalization of self control.

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CHAPTER ONE

INTRODUCTION

Society places a great emphasis on self control and many behaviours which society defines as problems can be seen as deficits in self control. For example, Werch (1990) describes deliberate strategies which a sample of American college students use to limit alcohol consumption. Individuals who often used self control strategies (such as finding other ways of socializing) reported lower alcohol consumption than those who did not use these strategies. This study has implications for helping people with alcohol related problems, as training in self control strategies may be useful in helping them gain control over their habitual drinking.

Criminal populations have also been described as lacking in self control. Wilson and Herrnstein (1985) propose a theory of crime. According to this theory, the larger the ratio of the rewards of noncrime to the rewards of crime, the weaker the tendency to commit crimes. Essentially, this theory describes a person who commits crime as impulsive. As part of their support for this theory, a study by Glueck and Glueck (1950) is described. In this study, non delinquents were found to be more self controlled than delinquents. This finding was based on Rorschach ink blot tests. This form of testing is extremely outdated.

Even if Rorschach tests were valid one test cannot describe a persons behaviour in the wide range of behaviours which are labelled criminal. This generalized kind of application is largely untested by research. It is unclear whether self control or impulsiveness will generalize to other behaviours or situations once it is learned in one behaviour or situation.

APPROACHES TO SELF CONTROL

Mischel's Personality Theory

Personality theorists have measured the development of self control in children as an indication of normal development. This line of research has investigated the role of attention in self control and has also focused on how self control develops. Mischel,Ebbesen and Zeiss (1972) conducted several experiments which demonstrated that children will wait longer to receive a larger reward when distracted from the reward than when either thinking about the reward or in the presence of the reward.

The method used involves leaving a child (age 3-5 years) in a room which contains a bell. The child chooses between ringing the bell and receiving a less preferred food item, or waiting until the experimenter returns of his or her own accord and receiving a preferred food item. In Experiment 1 the children waited with no distraction or were given a toy to play with or told to think fun thoughts. There were ten children assigned to each condition. All children in the non-distraction condition rang the bell. Of the children in the distraction condition, thinking fun thoughts led to longer waiting than playing with a toy (6 children in the fun thoughts group waited for the experimenter versus 4 children in the toy group). Using fun thoughts as a distractor was more effective than sad thoughts in Experiment 2; the mean waiting time was almost 3 times greater for the fun thoughts group.

These results are based upon objective research, but the explanations given for these results are in terms of reducing the aversiveness of the frustration which waiting produces. Mischel suggests that a subject maintains a behaviour which is associated with a delayed reward, by making an internal notation of the reward and then reduces his or her frustration at having to wait for the reward by attending to other stimuli. This kind of explanation suggests that remote reinforcers cannot be effective without a bridging mechanism, although other writers (such as Rachlin (1974)) regard this as " unnecessary".

Mischel's findings show that self-controlled responses occur in young children. It has been suggested that this self control develops in a 2 stage process (Sonuga-Barke et al 1989). Children aged 4-9 years are described as learning how to wait, and they become insensitive to pre-reward delays. In a second stage children learn when to wait for the larger more delayed reward. In other words they learn to make choices which will maximize the overall reward rate.

The evidence for this hypothesis came from a study where three age groups (4, 9, and 12 years) chose between two alternatives in an operant procedure called a "concurrent chains" procedure. The initial link schedules were VI 10s, and the choice in the terminal links was between one token delayed by 10s and 2 tokens delayed by 20-50s. The different age groups showed differing behaviour patterns. The 12 year olds strongly preferred the large reward initially, but as the pre-reward delay for the two token outcome increased from 20 to 50s, this group increasingly chose the small reward. The 9 year old group were insensitive to the changes in delay to the large reinforcer at all values. The four year old children were impulsive (chose the small more immediate alternative). These results are consistent with a 2-stage development process for self control in children.

A Behavioural Approach to Self Control

A behavioural approach to self control describes choice behaviour when a subject is choosing between two reinforcers of different sizes, with different delays associated with each. An organism is said to be self controlled when it waits longer to receive a larger reinforcer rather than choosing a relatively immediate, smaller reinforcer.

Mischel's procedure can also be seen as a behavioural approach to self control. In Mischels paradigm, children waited to receive a large reinforcer or pressed a bell to receive a smaller reinforcer immediately. This has been replicated by Grosch and Nerringer (1981) using pigeons and Skinner boxes.

In Grosch and Neuringer's study a trial began when a red keylight and a white overhead light came on. The subjects could peck the red key immediately and receive 1.5s access to a less preferred grain type, or could wait 15-20s until a more preferred reinforcer was presented (3s of access to mixed racing grain).

Mischel et al (1972) found that self controlled responses increased when the children were given a toy to play with. This toy was intended to distract the children's attention from the rewards. Grosch and Neuringer performed a pigeon analogue of this study by providing the pigeons with a key to peck at the rear of the cage. This key was illuminated and associated with either a fixed ratio (FR) 20 grain reinforcement schedule or the key was not associated with any grain reinforcement. The presence of the " toy " increased the percentage of pigeons which waited for the large reinforcer from 4% to 78% (toy plus FR20) and 76 % (toy without FR20). These results mirror those of Mischel at al (1972).

Mischel et al also ran a study where children were told to think fun or sad thoughts. To replicate this study with pigeons, Grosch and Neuringer added a conditioned positive stimulus (S+) and a conditioned aversive stimulus (S-) in the form of houselights and asked whether these would affect self control differently. The conditioned stimuli were established by 40 S+ and 40 S- discrimination trials where the S+ was followed by 3s of preferred grain and the S- was followed by 30s timeout. Thirty self control trials were held where either S+ or S- flashed for the duration of the delay. In the first session, the presence of the S+ led to longer waiting times than the S- but this effect was not present in subsequent sessions. Presumably, this is because the discriminative properties of the additional stimuli wore off.

In the study where the presence of a toy increased self control behaviour, the results were similar to those of Mischel et al but a different explanation can be given. Instead of saying that the toy reduced frustration, Neuringer suggests that responding to the toy was reinforced by an increased probability of receiving the preferred reinforcer after responding to it

BEHAVIOURAL MODELS

The Matching Law

The generalised matching law has been used to describe the response ratios which result when experimental subjects choose between reinforcers which differ along the dimensions of amount and delay of reinforcement. In this section, the effects of amount and delay on choice behaviour and how the matching law describes these variables will be looked at separately first and then together.

Amount of Reinforcement

Early research into concurrent schedule performance established a linear relationship between relative response rate and relative rate of reinforcement (Herrnstein,1961). These relations have since been extended to studies involving the relative amount of the reinforcer delivered each time. Catania (1963) found a linear reationship between averaged response rate and reinforcement duration in a concurrent VI 2-min VI2-min schedule. The duration of reinforcement was varied between 3 and 6s of grain access on each of two keys. Catania found that for each of the 2 concurrently available keys, the relative response rate on that key increased linearly as the reinforcement duration for that key increased. So, the linear relationship which Herrnstein (1961) found between relative response rate and relative .rate of reinforcement is similar to the relationship between reinforcement duration and response rate reported above.

Catania (1963b) discovered that the response rate on one of 2 concurrent schedules was inversely related to the rate of reinforcement in the other schedule. Rachlin and Baum (1969) used a similar method and showed that this relationship also holds for duration of reinforcement and response rate.

In Rachlin and Baum's study, a concurrent 3 min VI schedule was used. One key was always illuminated white unless grain was being presented. The other key was illuminated red, but only when a reinforcement was immediately available on the schedule operating on that key. This procedure reduces responding on the signalled (red) key and rules out the explanation that response rate on one key is inversely related to response rates on the other key. The duration of reinforcement was held at 4s for the unsignalled (white) key and was either 1, 4 or 16s for the signalled (red) key. The results showed that rate of responding on the unsignalled key varied inversely with duration of reinforcement on the signalled key (for 3 out of 4 pigeons).

Finally, Brownstein (1971) demonstrated a linear relation between the relative duration of reinforcement and relative time spent in the presence of a colour associated with a particular schedule could be found when reinforcement was response independent. Indepependent concurrent schedule were used. Each of the 2 schedules delivered a reinforcer every 1.5 min on average. One schedule was associated with a blue light and the other with an amber light . Pecking a response key changed the colour of the light (and hence the schedule available). The duration of the response

-independent grain presented varied between 1.5 and 4.5 sec. All the data points from this experiment were close to a diagonal line which represents 100% matching between relative duration and relative time spent in a schedule colour.

So, when the amount of reinforcement is varied in one of two concurrently available schedules of reinforcement, the larger reinforcer is preferred and this preference increases linearly as the amount of reinforcement is increased. These results can be summarized by the following equation:

$B1/B2 = (A1/A2)^{Sa}$ Equation1

where B equals the rate of responding and A equals the amount of reinforcement in one of two schedules of reinforcement. Sa measures sensitivity to amount, and has a value of 1.0 in a perfect matching result.

Delay of Reinforcement

The early research into delay of reinforcement in concurrent schedules asked if pigeons matched relative response rate to the relative immediacy of reinforcement. If this did happen, both amount and delay could be covered by the matching law. Chung (1965) reported a negative exponential relationship between the relative frequency of responding on a key and the delay to reinforcement for that key. In this study a VI 1 min

VI 1min schedule was used. The pre-reinforcer delay was varied between 0 - 28 sec for responses on a 'delay key'. Reinforcement was immediate on a 'non delay' key. To equate the reinforcement rate on both sides, intermittent blackouts were given to the non-delay key. These blackouts were the same duration as those given on the delay key.

A later study by Chung and Herrnstein (1967) argued that the data were better described by a matching relationship than by the negative exponential. Chung and Herrnstein varied the delay to reinforcement on an experimental key from 1-30s. On a standard key the delay was 8s for one group of 4 pigeons and 16s for another 2 pigeons. The relative response rate was found to be a function of the delay on both keys. For both groups a decreasing function was found between relative response rate and delay duration on the experimental key. However, when the delay on the standard key was 16s (rather than 8s) the function relating delay to relative response rate was displaced higher on the vertical axis. So, the relative reponse rate for one schedule matched the relative immediacy of reinforcement on that key, but was also affected by the delay in the other schedule (as shown by the displacement of relative reponse rate).

The data from this experiment slightly favoured the matching relation instead of a negative exponential. The authors also produced non-quantitative arguments to support the matching relation. The matching rule asserts that absolute levels of delay do not affect the relationship between relative immediacy (the complement of relative delay) and relative response rate. Hence, Chung and Herrnstein state that the matching rule is more powerful and restrictive than the negative exponential.

As relative response rate in one schedule matched the relative immediacy of reinforcement in that schedule, it can be said that the pigeons preferred the reinforcer which was less delayed, and as in the research into amount, this preference for the immediate reinforcer in creases linearly as the immediacy of reinforcement is increased (or conversely, as the delay decreases). These results can be summarized by the following equation:

$$B_1/B_2 = (I_1/I_2)^{Sd} \qquad \text{Equation 2}$$

where B measures the response rate, and I measures the immediacy of reinforcement in Schedule 1 or 2. Sd measures the sensitivity of responding to delay, and this parameter has a value of 1.0 when there is perfect matching between relative rate of reinforcement and relative immediacy.

Varying Amount and Delay Together

An organism is said to be self controlled when it waits longer to receive a larger reinforcer rather than choosing a relatively immediate, smaller reinforcer. The matching law has been used to describe behaviour when the reinforcers for two concurrent operants differ with respect to both amount and delay of reinforcement. In this equation, the measures of amount and delay are multiplied together as follows:

$B_1/B_2 = k\,(A1/A2)^{Sa} \cdot (D2/D1)^{Sd}$ Equation 3

In this equation, B_1 and B_2 refer to the number of responses made for each of two alternative reinforcers. The amount and delays associated with each of these reinforcers are given by A1 and A2 and D1 and D2 respectively. The constant k is a measure of response bias, whilst Sa and Sd represent a subjects sensitivity to changes in the size and delay of a reinforcer.

The value of a reinforcer declines the further away in time it is. Using information from the generalized matching law, delay curves can be plotted for an organism, which predict choice behaviour.

Figure 1 (McReynolds,Green and Fisher,1983), shows that the further away one is from both reinforcers, the more likely is a choice of the larger delayed reinforcer. At T2, preference reverses and the small immediate reinforcer is chosen after this time. An illustration of this is setting an alarm clock and placing it out of reach before going to bed. At this time, waking up early the next morning is chosen. In the morning the more immediate reinforcer (staying in bed) may be preferred as this is the equivalent of choice at T2. However this option has been prevented as the alarm clock needs turning off.

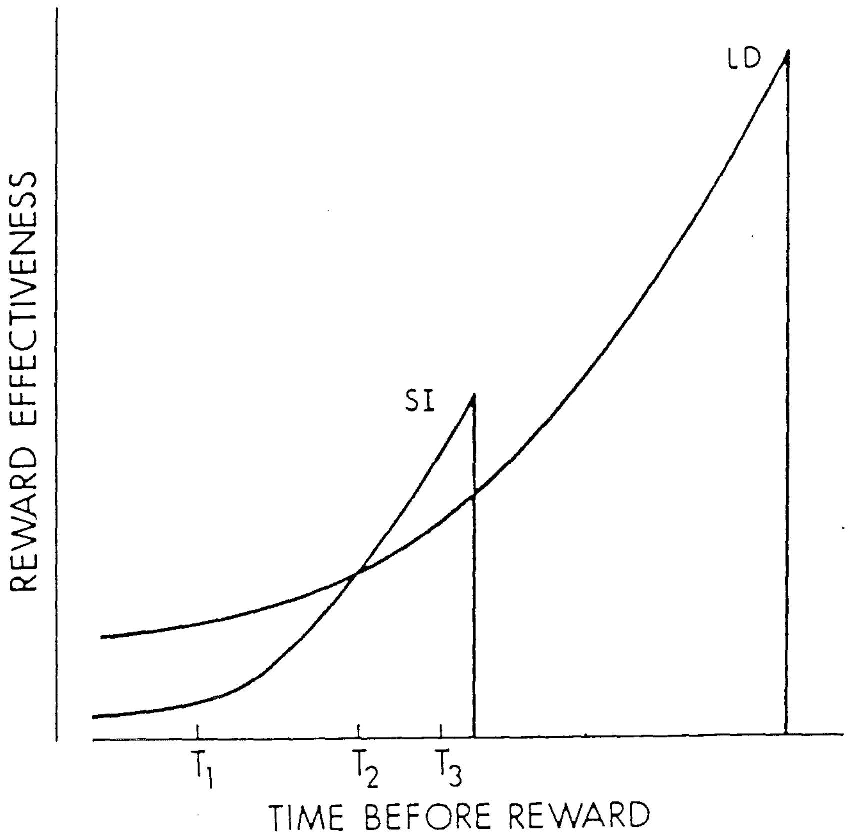


Figure 1. Reward effectiveness versus time before reward for SI, a small immediate reward and LD, a larger more delayed reward (McReynolds, Green and Fisher, 1983).

Animal Subjects.

When a delay, T is added to both of the existing, unequal, delay values in a self control paradigm preference has been seen to reverse. The matching law predicts that a subject will chose alternative 1 when A1.D2>A2.D1 and will reverse preference to choose alternative 2 when A1.D2<A2.D1 (Ito and Asaki 1982).

Ainslie and Herrnstein (1981) demonstrated preference reversal in a discrete trials procedure. As the remoteness of both choice alternatives increased the pigeon subjects reversed preference to choose the larger later reinforcer on most occasions. The choice was between 2s of grain delayed Ds versus 4s grain delayed D+4s. D was initially equal to 0.01s and was then increased in intervals to 12s with a final 0.01 condition for half of the subjects or increased abruptly to 12s and then decreased by intervals to 0.01 for the remaining subjects.

Mean preference for the large-late reinforcer changed from being <0.1 (initial condition:D=0.01) to > 0.9 (D=12s). For 4 out of 6 birds this preference change reversed again when D was returned to 0.01. The indifference (or crossover) point, when alternative 1 is equally preferred to alternative 2 occurred in this experiment when D was between 4 and 5s on average. A prediction based on the matching law cites P= 4s as the indifference point. This study uses the unexponentiated version of the matching law. Without the free parameter which describes the sensitivity of response ratios to changes in delay ratios, the matching law would not be as accurate in it's predictions. However, in this case the predicted indifference point is not far off the observed value.

Ainslie and Herrnstein added feeder latencies to the scheduled delays and calculated an alternative crossover point for 4 birds when d is between 6 and 8 sec. Two out of 4 birds crossed in this interval. So, both predictions are approximately correct. One problem with this study is the use of independent schedules. This allows the formation of a feedback relation between preference and reinforcer rate. A Stubbs and Pliskoff (1969) procedure could be used to ensure that obtained and programmed reinforcer rates are consistently equal. In this procedure a reinforcer is randomly assigned to either terminal link when it becomes available. So each terminal link is entered equally often. This can penalise exteme preferences as responding on one key will be ineffective if a reinforcer is currently available on the other key.

Studies of Delay and Amount Involving Human Subjects

In a self-control paradigm where subjects are choosing between a small, more immediate reinforcer and a larger delayed reinforcer, contradictory results have been found. Both impulsiveness and self control have been demonstrated using human subjects. Logue, King, Chavarro and Volpe (1990) suggest that the type of reinforcer used may have an effect on these results. Navarick (1982) used negative reinforcement in the form of termination of an unpleasant noise. A discrete trials procedure was used. At the beginning of each trial, subjects were exposed to noise for 10s with the 2 response keys unlit and inoperative. At the end of this time the keys are illuminated red and a choice phase occurs. For one group of subjects, this choice was between 5s of immediate silence followed by 90s noise versus 75s of noise followed by 20s of silence. The mean choice proportion for the smaller immediate reinforcer was 0.8.

This finding of impulsiveness is supported by the results of Ragotzy, Blakely and Poling (1988), who used edible reinforcers (1 or 3 cocoa puffs). Ragotzy et al (1988) found that 3 mentally retarded adolescents reversed a preference for a large reinforcer (when both reinforcers were presented immediately) to a preference for a small reinforcer when the large reinforcer was sufficiently delayed (mean delay =20s). At the start of Phase 1, neither reinforcer was delayed. In a second condition the large reinforcer delay was increased in multiples of 5s until the number of large reinforcers chosen was less than 20%. In Phase 2, initially the small reinforcer was presented immediately , and the large reinforcer was delayed by the value that shifted preference to the small reinforcer in phase 1. Delays of 5s were added to each choice until subjects chose the large reinforcer on more than 80% of choices.

When neither reinforcer was delayed, all subjects chose the large reinforcer on more than 80% of trials. As the delay before the large reinforcer increased, preference for the large reinforcer decreased until all subjects chose the large reinforcer on less than 20% of trials (mean delay =20s). In Phase 2, 2 out of 3 subjects increased large reinforcer choices when the delays to both the small and large reinforcer were increased.

These results, and those of Navarick (1982) agree with non-human data. People will behave impulsively when the delay before the large reinforcer is sufficiently long. Both of these studies used 'primary' reinforcement , as do animal studies.

Logue, Pena-Correal, Rodriguez and Kabela (1986) used conditioned reinforcers and found that their subjects chose the large reinforcers more often than predicted by the matching law. That is, they were more self-controlled than predicted. The reinforcer used was a system of points which could be exchanged for money at the end of a session. During a reinforcement period each key press increased a points total by 1. So, reinforcer amount is measured in seconds of access to the key which provides the opportunity to earn points. The amount of reinforcement varied from 1-12s of key access and delay of reinforcement varied from

0.1 to 120s. The subjects (adult females) chose a lower proportion of the smaller less delayed reinforcer than predicted by the matching law in all conditions. Furthermore, subjects showed a preference for the larger delayed reinforcer in 35 of 46 conditions.

The type of reinforcement used in these studies may have an effect on whether subjects show exculsive self control. Primary reinforcement has been delivered immediately. White noise is terminated instantly and food is instantly consumed. However, using points which are exchangeable for money at the end of a session, does not provide such immediate reinforcement, and this complicates the interpretation of results from such studies in terms of delay of reinforcement.

The Delay Reduction Model

Fantino's (1969) model states that preference is determined by the reduction in delay to primary reinforcement in one alternative relative to the other alternative. The equation which describes this is as follows:

$B_1 / B_1+B_2 = T-t_1 / (T-t_1)+(T-t_2)$ (when $t_1<T_1$, $t_2<T$) Equation 4

$=0$ (when $t_1>T$, $t_2<T$

$=1$ (when $t_2>t$, $t_1<T$)

where B_1 and B_2 represent responding on the two alternatives during the initial link, T is the mean time to primary reinforcement from initial link onset, and t_1 and t_2 are the two terminal link intervals. The delay reduction model has also been applied to the choice between self control and impulsiveness. In this application, the way an organism chooses between 2 responses, relates to the delay to reward of those 2 responses. Conditioned stimuli are said to bridge the gap between responses and delayed reinforcement. So, the choice made depends on the strength of the conditioned reinforcers for each of the 2 responses.

Optimal Foraging

Optimal foraging research assumes that animals will behave in ways which maximize energy intake rates, within certain constraints. Models in this area assume that (a) prey are encountered randomly, (b) the predator can instantly recognize a prey type and (c) the predator knows the net energy gain and encounter rate of each prey type. While this research seems very different to models of self control, there are still situations where the predator is choosing between reinforcers of different sizes with different delays associated with each. This research is therefore relevant to self control research which also involves choosing between reinforcers of different sizes and delays.

The decisions which a predator makes are based on the total energy gain rate associated with a particular diet. Snyderman (1983) presents the following decision rule.

$$\frac{R_1E_1}{1+R_1h_1} < \frac{E_2}{h_2} \qquad \text{Equation 5}$$

In this equation E_i is the net energy gain, h is the handling time, and R1 and R2 respectively, are the rates of encounter with more and less valuable prey types. In normal circumstances, a predator would always choose the more valuable prey. The inequality above models how a predator chooses to take a diet which also includes less preferred prey. The left side measures the total energy gain rate received from eating only the more valuable prey. The right side measures total energy gain rate for a diet including both prey types.

In the situation above, a predator generalizes and consumes a less valuable prey as the energy received from specializing (consuming only more valuable prey) is less than the energy received from a diet consisting of both types of prey.

This model assumes that animals always maximize. However research from a behavioural perspective has shown that animals can be impulsive in a self control paradigm (ie the animals do not maximize energy intake).

Optimal foraging research was originally carried out in the natural environment but research has increasingly being carried out using procedures where it is possible to have more control over the independent variables. Optimal foraging research has come into contact with behavioral research into self control as optimal foraging theories have been tested using the behavioural methodologies.

Snyderman (1983a) asks whether ecologists have underestimated the importance of the delay from recognition to consumption. In an optimal foraging model, the value of prey is determined entirely by the energy gain rate during the handling period. The handling period is the time from initial movement of the predator to capture, preparation time, time for consumption and any time that is required to return to the search state. In an operant self control paradigm, the handling time is therefore equivalent to the prereinforcer delay, plus the post reinforcer delay. The structure of this handling period may be important as operant research into self control has shown post reinforcer delay to be less important than pre-reinforcer delay. Logue (1985) found that pigeons are sensitive to post reinforcer delays only when rate of reinforcement is affected. However, pigeons are sensitive to pre-reinforcer delays regardless of the rate of reinforcement.

To test whether the structure of the handling time was important Snyderman (Experiment 2 1983a) placed four pigeons in a "search" state. While in this state two variable interval (VI) schedules ran simultaneously. When these schedules timed out the pigeons pecked 3 times during a recognition period to choose either a small or large prey. The handling times associated with both of these prey were the same duration, but were structured differently. Capturing a large prey led to 4s blackout, followed by 6s grain access and a return to search state. Capturing a small prey led to 1s blackout followed by 2s grain access and 7s blackout. The crucial difference was the delay before the grain access (4 s before the large prey and 1s before the small prey). This procedure increased the proportion of small prey taken. This demonstrates the importance of pre-reinforcer delay, and indicates that optimal foraging models need to account for prey selection in terms of delays.

STUDIES OF SELF CONTROL

Varying Absolute and Relative Delay.

The matching law predicts matching of relative response rates to the relative immediacy of reinforcement. The absolute delay is not predicted to affect choice. However, research has shown that absolute delay values are an important predictor of choice. Gentry and Marr (1980) conducted an experiment where the relative delay of reinforcement was kept at 0.8 on a short-delay key by ensuring that the long delay was always 4 times longer than the short delay. The reinforcer provided was equal for both keys (3s of grain access). The main result of this experiment was that relative frequency of responding matched relative immediacy of reinforcement only in the mid range of delays. Again, a VI 1 min VI 1 min schedule was used. A non-independent method of delivering reinforcers was used to prevent the effects of delay of reinforcement being confounded with the relative frequency of reinforcement.

A wide range of delays were used. The delay key varied from 1-128s and the short delay key varied from 1-32s. The total duration of the reinforcement sequence was maintained at equal levels for both keys by manipulating the length of past reinforcement blackouts. The relative frequency of responding on the short delay key, only matched the relative immediacy of delay at mid-range delays (approximately 8s). At higher or lower delay values the preference shown was lower than that predicted by the matching line. So absolute delay values are important. It is possible to see this experiment as a concurrent chained schedule; the terminal links being fixed time (FT) schedules equal to the length of the scheduled delay. This allows the application of models such as the delay-reduction hypothesis which were developed using concurrent chain procedures.

Ito and Asaki (1982) demonstrated the relevance of absolute delay lengths when the relative delays in each schedule are equal and reinforcer amounts are unequal but constant. A concurrent chain was used with the initial links being a VIVI 60s and the terminal links being FI schedules of equal delay (5,10,20 or 40s). The amount of reinforcement was either 1 or 3 food pellets, given in a 6 sec period. Preference for the large reward increased as both delay intervals increased, even though the ratio of reinforcement was constant. For example, subject R5 showed an increase in large reinforcer choice proportion from approximately 0.6 (5s delays) to 0.85 (40s delays). For 11 out of 14 rats these preferences also reversed when the delays of equal duration decreased. This change is not predicted by the matching law because the ratio of A1.D2 : A2.D1 in this experiment is 1:3 regardless of the absolute level of the delays in the terminal links.

Ito and Asaki investigated the role of absolute delay length in concurrent chain schedules using equal delays in both terminal links, that is a 1:1 delay ratio. Green and Snyderman (1980) used 3 delay ratios (6:1, 3:2 and 3:1). Two reinforcer durations were used (2 and 6s). Each ratio was constant within a condition while the absolute delay varied. The large delay was associated with the longer reinforcer duration.

In the 6:1 and 3:1 ratios, preference for the longer delay decreased as the absolute delay to reinforcement in the terminal link increased, However, in the 3:2 delay ratio, preference for the longer delay increased as absolute delays increased. These findings have implications for both Fantino's (1969) model and the generalised matching law.

The delay reduction model predicts that as absolute delays increase, preference for the longer delay will decrease in the 6:1 condition, will stay the same in the 3:1 condition and will increase in the 3:2 condition. The predictions by Fantino's (1969) model for the 6:1and 3:2 delay ratios were confirmed by Green and Snyderman (1980). However, Snyderman (1983b) repeated this experiment with two modifications.

Non-independent concurrent schedules were used and the length of the terminal links were equated by the use of post reinforcement blackouts. This study confirmed Green and Snyderman's results for the 6:1 ratio and 3:1 ratio condition and also found that preference for the longer delay decreased as absolute delays increased in a 3:2 delay ratio. As Snyderman (1983b) corrected criticisms of Green and Snyderman (1980), Fantino's model can only be said to predict the results in a 6:1 delay ratio.

The generalized matching law accurately predicts all the results of this experiment, when Sa=1 and Sd=1.5. The use of free parameters in the matching law enables this model to account very well for the results of Snyderman's (1983b) study. However, the use of these parameters limits the ability of the model to predict future results. The generalised matching law is still an extremely useful model when you consider that it can account accurately for individual differences and differences based on past experience.

The results from the 3:1 ratio indicate that delay is a more important determinant of choice than amount. This is shown by the decrease in preference for the longer delay as absolute delays increased, as amount and delay ratios were equal and opposite in the 3:1 condition. The Sd value which was fitted to the data confirms the potency of delay as the longer exponent (Sd=1.5) shows that reinforcer value declines more quickly as a function of delay. When reinforcer value declines more quickly, the small reinforcer is more likely to be chosen over a greater period of time.

It has been shown that preference for a larger reinforcer increases when absolute but not relative delay duration is increased (Ito and Asaki,1980; Green and Snyderman,1980; Snyderman,1983). White and Pipe (1987) suggest that as a delay T is added to both pre-reinforcer delays, the sensitivity to the ratio of reinforcer durations (a) may increase. White and Pipe researched this idea using a concurrent chain with FI 5s shedules in each initial link. The basic delays were 0s (left) and 6s (right). An added delay (T) was equal to 1, 2.5, or 10s for the first 5 conditions and 0, 5, or 20 for conditions 6-10. During the choice phase, the colour of the response keys signalled which T value was operating. Unlike other studies, the key which had produced the delay remained illuminated during the delay interval.

The results of this study reconfirmed the occurrence of preference reversal, and showed that sensitivity to reinforcer amount changes as a function of T. Preference reversal was demonstrated by combining data involving 2 sets of reinforcer durations (1 versus 5 s and 2 versus 4 s). When the proportion of large reinforcer choices is plotted against T (the added delay), subjects are seen to reverse a preference for the smaller reinforcers at T=0 or 2.5s to a preference for the larger reinforcers at T= 10 or 20s.

For 4 out of 5 birds the values of a (sensitivity to amount) increased systematically as T increased. White and Pipe report that the function between these 2 variables appears to be hyperbolic and has an asymptote at about a=1.5. Experiment 1 was repeated using equal delays in tha left and right terminal links to determine if the changes to sensitivity of amount reported above, are a function of the absolute delay to reinforcement. For this experiment T values were 1. 5. and 20 s. The results of this study showed that sensitivity to reinforcer durations was higher at longer absolute delay durations and lower at shorter absolute delay durations. So, preference reversal may be due to the change in sensitivity to reinforcer duration that occurs as T increases. Indeed, the functions displaying preference reversal and changes in a with T variation partly mirror each other.

PROCEDURES WHICH INFLUENCE SELF CONTROL

Self control has been shown to be an important part of everyday life. If self control could be increased many of society's problems could be aided to some extent. This section reviews the research which has investigated procedures which influence self control in behaviour.

Commitment

Preference reversal predicts that preference for a small immediate reinforcer will increase as the time to obtain this reinforcer comes closer. Commitment holds an organism to the choice it makes or would make when both reinforcers are distant in time. A commitment procedure is made before the small reinforcer is desirable and prevents later choice of the small reinforcer when it is likely to have become more preferable than the large reinforcer.

Commitment with Pigeons

Rachlin and Green (1972) and Ainslie (1974) have both demonstrated commitment using pigeons as subjects. Rachlin and Green gave pigeons the choice of commiting themselves at Point B (see Figure 2)to a larger delayed reinforcer after Ts or waiting Ts until they could choose at Point A between a small immediate or a larger delayed reinforcer. The large reinforcers were 4s of grain delayed by 4s. The small reinforcer was 2s of grain delivered immediately. The value of T was gradually increased from 0.5 to 16s and then decreased again.

When the pigeons chose directly between the large and small reinforcers (Point A), the small reinforcer was taken on more than 95% of trials. However, as the delay T increased all birds increased their preference for the commitment option. At T=16, 4 out of 5 birds chose this commitment response, whereas 4 out of 5 birds chose the small reinforcer at T=0.5.

This demonstrates that commitment can work, as it increases the probability of choosing the self control option. The pigeons mostly chose the small reinforcer when it was immediately available, but as the delay before this choice increased, they learnt to commit themselves to a large delayed reinforcer and avoid choice Point A.

Ainslie (1974) approached this slightly differently. Ainslie felt that the immediate reinforcement in Rachlin and Green's experiment was delayed too much by the 25 pecks required in the initial link. In Ainslie's experimental condition, pigeons pecked a key to commit themselves to a larger delayed reinforcer. Not pecking led to a later choice between 2s of immediate grain access and 4s of grain delayed by 2s. The value of T was held at approximately 4.5s. Only 3 subjects learnt the commitment response, but these subjects maintained this responding. In a control condition where pecking the green key did not lead to a commitment option, responding dropped on the green key. So, commitment occurred in only a few birds, but was sensitive to the changes which were introduced in the control condition.

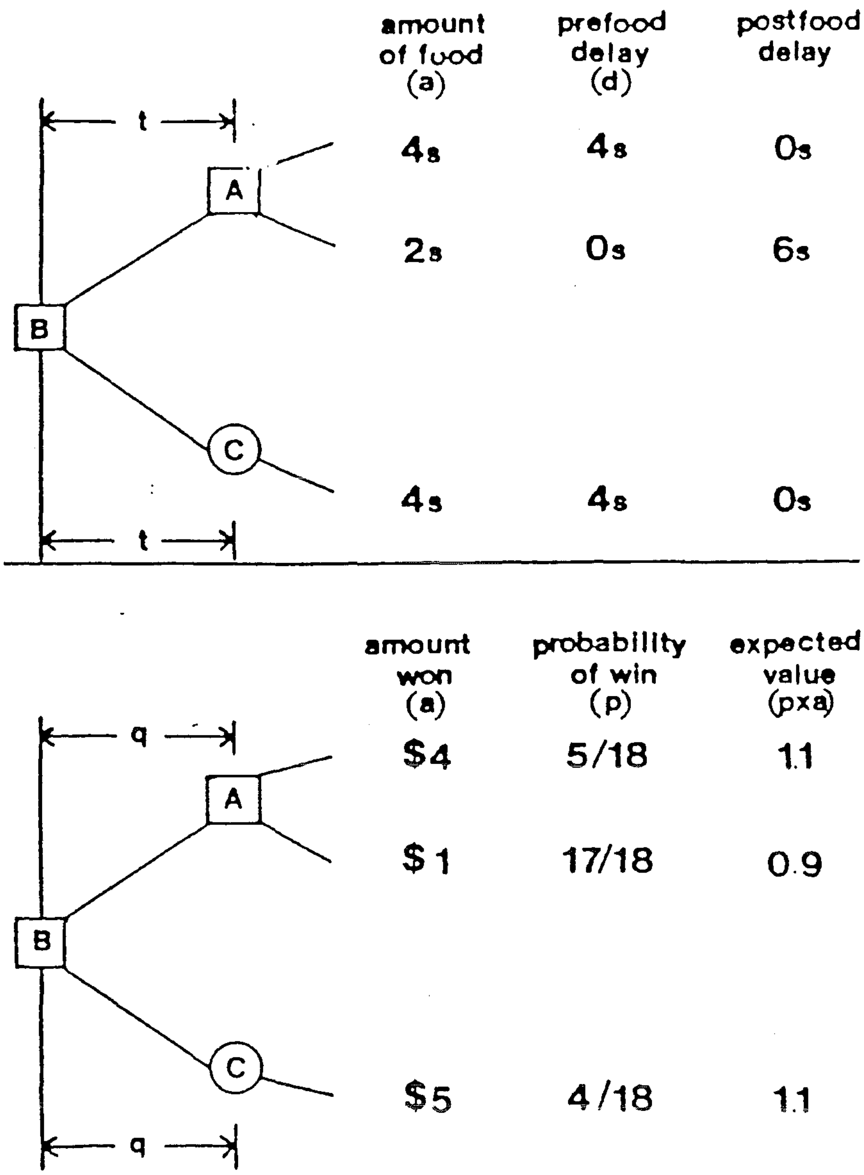


Figure 2. The top panel represents the choice structure for the commitment paradigm used by Rachlin and Green (1972). The lower panel shows the analogous paradigm used by Rachlin, Castrogiovanni and Cross (1987), using human subjects, choosing between rewards with varying probabilities.

Commitment with people

In 1954 Rotter suggested that probability and delay were subjectively equivalent. People who were impulsive were thought to believe that remote rewards were unlikely to be delivered. Rachlin, Castrogiovanni and Cross (1987) suggest that delay is the fundamental variable which underlies commitment studies using either delay or probability. Rachlin demonstrated a commitment procedure using human subjects and probabilities instead of delays. Each subject was given 10 red and 10 blue poker chips. These colours represented 2 different probabilities. A subject placed these on choice points A or C and access to choices A or C was allowed if a spinner landed on the chosen probability range. These initial probabilities (q) were equivalent to T in Rachlin and Green (1972). At choice point A, subjects chose between a $4 win with a 5/18 probability or a $1 win with a 17/18 probability. Choice point C was a commitment procedure which restricted a subject to a $5 win with a 4/18 probability.

As in Rachlin and Green's study, when subjects were at point A, they mostly chose the small reinforcer (72%). However, at point B, more than 50% of subjects chose the commitment response (C). So a high preference for the small reinforcer at point A, has changed to indifference at B as the probability decreased. This is equivalent to the increase of T in Rachlin and Green. The matching law has difficulty accounting for the results of a commitment procedure which uses probabilities as probabilities multiply and so cancel out. Rachlin et al (1987) converts probabilities to delays. Using this conversion the matching law does explain the effect of q on choice.

Experience of Long Delays.

An experiment by Eisenberger et al (1982) has led to the suggestion that experiencing a long delay between rewards may increase subsequent choices of a larger more delayed reinforcer. The rats in this experiment were divided into 4 groups. A fixed ratio 80 (FR 80) group received a pellet for every 80 bar presses. A paired rat in a long duration group received a pellet every time its partner in the FR 80 group received a pellet. The continuous reinforcement and short duration groups were similarly paired. This training continued for 12 days. To test how this training affected self control behaviour, all rats were run in a T-shaped maze for 48 trials, before and after the training. In one goal arm 1 pellet was available after a delay of 1s. In the alternative arm 3 pellets were available after 12s.

After comparing the rats behaviour in the T-maze before and after training Eisenberger et al (1982) concluded that exposure to long delays between rewards led to more subsequent self control than experiencing short delays. However, experiencing higher effort per reinforcement did not have an effect on subsequent self control in the T-maze. The results of this study are important as they suggest that the effects of commitment (increased experience of the long delay) may persist even when commitment responses are no longer available.

Deprivation

Various studies have investigated what effect food deprivation has on self control but no consensus of opinion has been reached.

Eisenberger et al (1982) manipulated hunger level across two choice tests with rats as subjects. High hunger groups performed trials 20-22 hours after daily feeding and low hunger groups were tested 2-4 hours after feeding. The choice tests consisted of 48 trials in a T-maze. Test 1 was between 1 pellet delayed 1s and 3 pellets delayed by 12s. In Test 2 rats chose between 1 pellet delayed 1s and 7 pellets delayed by 32s. Eisenberger et al (1982) found that hunger had a significant effect on large reinforcer choices only in Test 2. In other words, increased deprivation led to increased impulsiveness only when a larger difference in delay was involved.

This finding is backed up by Snyderman (1983c) who manipulated deprivation in pigeons by reducing free feeding body weights. An optimal foraging design was used. Two simultaneous VI schedules were used to simulate encounter rates with 1 large and 1 small prey. When either of these schedules timed out the subject had 2s in which to make 2 pecks at a response key (recognition time). If these pecks were made, the subject went into handling time. For the large prey, handling time consisted of 4s blackout, followed by 6s of grain access. Handling time for the small prey consisted of 1s blackout, 2s grain access and 7s blackout in that order. So, reinforcer size differed but length of handling was equivalent.

The two VI schedules (encounter rates) were varied across conditions and all pigeons were run through the experiment at 95% of free feeding weights and then at 80%.

The main effect of the increase in deprivation was to increase impulsiveness. Subjects changed from selecting mainly large prey to selecting both types of prey, at the expense of overall energy gain rate. This is well demonstrated by a condition where the encounter rate for large prey was twice that of small prey (1/VI=0.1 (large prey) and 0.2 (small prey)). To optimize energy gain all subjects should have chosen the large prey only. This prediction was confirmed at 95% of free feeding weights. However at 80% all pigeons were generalizing (ie taking both prey types).

Both of the above experiments found that deprivation increased impulsiveness. Eisenberger et al (1982) found that this only happened when larger differences of delay were involved, and Snyderman found increased impulsiveness, even when the rate of reinforcement was larger for the larger prey. However Logue and Pena-Correal (1985) found food deprivation to have no effect on large reinforcer choice, and Christensen -Szalanski, Goldberg, Anderson and Mitchell (1980) found that water deprivation led to increased self control using water access as the reinforcers.

Logue and Pena Correal investigated food deprivation effects by running pigeons through a discrete trials procedure at 65%, 80% and 90% of free-feeding weight. Thirty four trials per session were carried out where pigeons chose between 6s reinforcement delayed by 6s and 2s of reinforcement delayed by xs (x was between 1 and 6 s). A new trial was held every minute regardless of which alternative a subject chose.

Large reinforcer choices were not significantly affected by deprivation level in this experiment. Eisenberger et al (1982) found that larger differences in delay were required before deprivation had an effect. In this study deprivation had no effect even when the delay to the small reinforcer was 1s (the greatest difference between the two delays, much smaller than the 1s versus 32s in Eisenberger et al's study).

Christensen-Szalanski et al (1980) studied self control in rats which had been subjected to past and/or present water deprivation. In the past deprivation condition half of the rats were given 10g of water daily until their weight had reached 70% of ad lib weights. This deprivation continued for 2 months. Ad lib weights were then recalibrated for one month. For the present deprivation condition, half of all groups were taken down to 70% of ad lib weights by reducing water access. To test the effect of deprivation on self control, all rats were given a choice between a large water reinforcement (0.25 g) delayed by 10s or a small water reinforcement (0.05 g) delayed by xs and followed by 10-xs of blackout. The value of x was varied from 0 to 7.5s.

In line with research into amount and delay, as the delay to the small reinforcer increased, preference for the larger reinforcer increased. However, contrary to Eisenberger et al (1982) and Snyderman (1983c), deprived subjects showed a greater preference for the delayed large reinforcer, regardless of whether deprivation was past or present. The deprivation in this study involved water, not food so perhaps the contradictory result is due to a difference between the effects of water and food deprivation. If this is true then it is reasonable to suggest that food deprivation leads to decrease in self control provided that the difference between the two alternatives is large enough.

Fading procedures

The idea of a fading procedure came from Ferster (1953), whose work led him to suggest that a subject's behaviour towards a particular delay is affected by the way a delay is introduced. A fading procedure involves gradual changes along some stimulus dimension. In a self control paradigm a fading procedure refers to gradual change in the delay associated with one of two reinforcers.

Mazur and Logue (1978) used a discrete trials procedure. This involved giving the subjects 34 trials, with one trial taking place every minute. Pecking a left key produced 6s of grain access delayed by 6s. A right key peck led to 2s of grain access delayed by xs. The value of x was initially 6s but this was decreased to 0s in 17 steps. A control group ran for 24 sessions with x at 0s and 28 sessions with x at 5.5s. The figure 5.5 was chosen because at this delay all pigeons almost exclusively chose the large delayed reinforcer. An interesting system of keylights was used in this study. The left key was illuminated green and pecking this key led to the appearance of a green houselight during the delay and reinforcement periods, and the right key, similarly, produced a red houselight during delay and reinforcement periods.

Preference for the large reinforcer was almost exclusive at small reinforcer delays of 3.25s or longer. As x came closer to 0s, preference for the small reinforcer increased but even in the 0 s condition there was still a significant difference between the experimental and control groups. When x=0s the experimental group chose the large reinforcer 55.9% of the time compared to 2.5% for the control group. These results show that the fading procedure did increase self control behaviour. However, it is not clear which aspect of Mazur and Logue's procedure is responsible for the change in preference or how general this change is. Two factors which may be responsible for the increased self control in this study are the gradual change in the small reinforcer delay and the large number of trials.

A replication of this study was run by Logue, Rodriguez, Pena-Correal and Mauro (1984). The control group was exposed to all of the fading steps for 3 sessions rather than just the initial and final conditions as in Mazur and Logue (1978). This was done to control for the degree of exposure to the fading steps required to increase large reinforcer choices. Apart from this difference procedures were almost identical. Again, this procedure led to an increase in large reinforcer choices. However, the control group preferences approached the experimental group's results until a reversal condition was run where the contingencies for the two keys were swapped. The reversal condition led to very large decreases in the number of large reinforcer choices in 2 out of 3 members of the control group. However, in the experimental groups, 6 out of 7 pigeons showed small increases in large reinforcer choices.

Apparently, experiencing three sessions of each fading step in the control group was enough to establish a position bias, but not enough to strengthen self control sufficiently, so that the reversal condition did not remove it. A higher preference for the large reinforcer when x=0 was still shown by Logue et al's control than by the control in Mazur and Logue (1978). So experiencing even a few sessions in each condition was effective to some extent. It would be interesting to discover how many sessions per step are required to institute self control to the same level as in Logue et al's experimental group where the number of sessions per condition varied between 10 and 54. Eisenberger (1982) suggests also that experiencing long delays may be sufficient to increase self control without using a fading procedure.

An interesting observation from Mazur and Logue (1978) is that large individual differences occur. The percent of large reinforcers chosen by the experimental group when x=0 varied from 13 to 90%. As described earlier there are also differences between pigeons and humans in studies which involve delay and amount. The question then arises whether the results of fading studies using pigeons are relevant for other species.

Van Haaren et al (1988) performed a variation of a fading procedure using rats. An initial choice (Conditon A) was between 1 pellet and 3 pellets. Both reinforcers were delayed by 6s. In condition B, the delay to the small reinforcer was decreased from 6 to 0.1s. After this, contingencies for each lever were reversed. The number of sessions for conditions A and B were 16 and 28. After only 16 sessions in the equal delay condition, all rats chose the large reinforcer on almost 100% of trials. When the delay to the small reinforcer was decreased to 0.1s in the next condition, 15 out of 16 subjects chose the large reinforcer on more than 80% of trials. This is very different to the results found using pigeons where hundreds of trials carried out during a gradual fading procedure led to a much smaller increase in self control.

Fading procedures have been used with children defined as impulsive or hyperactive. Schweitzer and Sulzer-Azaroff (1988) gave children a choice between 1 or 3 reinforcers. The subjects were 6 preschoolers. Initially the reinforcers were both presented immediately. The delay to the large reinforcer was then increased by 5 s increments, each time a performance criterion was reached (the large reinforcer was chosen on 4 out of 5 trials). Indifference points were calculated before and after training to assess changes in self control. An indifference point occurs at a delay where the subject chooses the large and small reinforcers equally often. There was a significant difference between pre and post-training indifference tests. Four out of five subjects were indifferent at much larger delays to the large reinforcer. For example, one subject had a pre training indifference point of 1.7s and a post-training indifference point of 37.5s. The training procedure was effective in increasing choices of a large reinforcer in this situation but no data are given on the childrens' subsequent classroom behaviour.

It has been suggested by Logue and Pena-Correal (1984) that fading procedures only work because the subjects have no opportunity to change their choice during the delay to the large reinforcer. To test this idea a fading procedure was set up where a subject could still choose to receive a small immediate reinforcer during the delay to the large reinforcer. The fading procedure started with 2 reinforcers (6s or 2s grain access), both delayed by 0.11s. Over 21 conditions the delay to the large reinforcer was increased from 0.11 to 6s.

Three of the 8 pigeons in this study never changed their choice while waiting for the large reinforcer. The remaining pigeons waited less as the delay to the larger reinforcer increased. Contrary to Logue and Pena-Correal's suggestion, fading procedures do work even when the subjects have the opportunity of altering their choice to a choice for the small reinforcer during the delay before the large reinforcer.

INTERPRETATION OF FADING RESULTS IN TERMS OF THE BEHAVIOURAL MODEL

In an earlier section it was noted that the choices which subjects make seem to be more sensitive to delay ratios than to amount ratios. During a fading procedure, subjects become relatively more sensitive to reinforcer amount ratios than to reinforcer delay ratios. This change can be described by the sensitivity parameters (Sa and Sd) of the generalized matching law. These parameters can be determined in two ways. Firstly, at an indifference point the sensitivity ratio (Sa/Sd) can be evaluated using the following equation.

$$Sa/Sd = \log(D_1/D_2) / \log(A_1/A_2) \qquad \text{Equation 5}$$

This assumes there is no response bias. Alternatively, the individual exponents can be calculated by varying reinforcer size or delay in a concurrent VI schedule. If log response ratios are plotted against amount (or delay ratios), the slope of the line is equal to Sa (or Sd). The equation for amount-ratio variation in this situation can be written as:

$$\log(B1/B2) = Sa \log(A1/A2) + \log k \qquad \text{Equation 6}$$

So, Sa is equal to the slope of the line and log k gives the log of the response bias.

Table 5 (Logue et al. 1984) reports Sa/Sd ratios for both fading exposed and non-fading exposed subjects. While there is no one ideal ratio, the fading subjects show significantly higher sensitivity ratios. This indicates that sensitivity to amount relative to delay was larger after exposure to a fading procedure. The experiments referred to in Table

5 all used pigeons. Schweitzer and Sulzer-Azaroff (1989) carried out a fading procedure using children. Because they clearly identified indifference points before and after fading for Subject E, it was possible for the present author to calculate pre and post training sensitivity ratios for this subject. The ratio before training was 2.6 and the post fading ratio equalled 5.4. Sensitivity ratios are therefore useful in describing behaviour in a self control paradigm, as the general effects of a procedure can be discovered even if the exact magnitude of these effects can not be.

The effect of subjects becoming relatively more sensitive to reinforcer amount than delay (increased sensitivity ratio) can be clearly seen by drawing a hypothetical delay curve.

In the top panel of Figure 2 (Logue et al. 1984) both Sa and Sd equal 1. This is the situation described by the strict matching law.

In the bottom panel Sa > Sd. The indifference point in this panel has shifted to the right, so that at both times 1 and 2, the larger reinforcer is preferred.

When Sa =Sd the small earlier reinforcer is preferred at Time 1 and the large later reinforcer is preferred at Time 2.

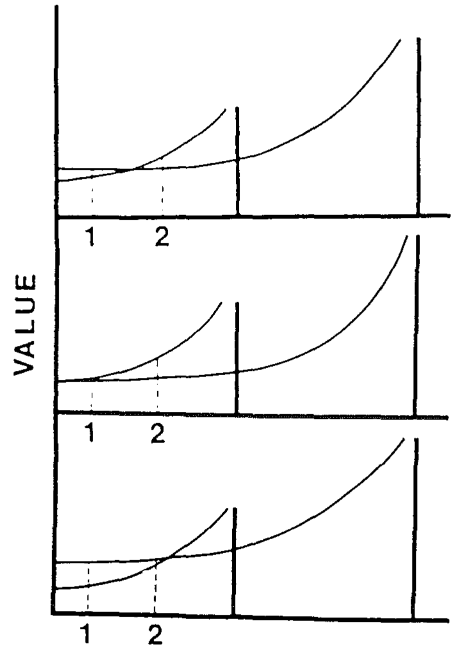


Figure 3. This diagram shows how the value of two reinforcers, one large and one small, changes as a function of time when the ratio of sensitivity to amount (Sa) to sensitivity to delay (Sd) differs.

GENERALISATION OF ACQUIRED SELF CONTROL

Self control has been defined here as the choice of a larger later reinforcer in preference to a smaller more immediate reinforcer. A number of procedures have been shown to increase the choices of a larger later reinforcer in an experimental situation. Certain theorists have assumed that self control which has been learned in one choice will generalize to other choices. For example, a criminal population has been described as generally lacking in self control, but it is not clear how specific or general self control is.

The implications of this are far-reaching. If an increase in self control easily generalizes to other behaviours, then people who were trained to overcome a specific self control deficit would aso be able to control many other areas of their lives. It follows from this notion that a person could be expected to exhibit self control in either a majority or a minority of their behaviours. Conversely, if self control only generalizes to very similar situations then improving self control performance in one behaviour would have little effect on the person's remaining behaviours. If this idea is correct then a person could be expected to show self control in some behviours but not others. It would not be such an all or none trait. The implications of this for reducing criminal behaviour, for example, would be that a person would need to be trained in many areas. For example, reducing car thefts would not reduce cheque fraud.

A number of researchers have addressed the issue of generalisation. Generally, these researchers have discovered that self control learned in a fading procedure will generalize across time and to other schedules. Self control involving effort generalizes to other behaviours which are rewarded for high effort.

Generalisation to Another Schedule

Logue et al (1984 Experiment 2) introduced 7 pigeons into independent concurrent VI 30 s VI 30s schedules. Three of these pigeons were previously trained in a fading experiment. In 2 conditions reinforcer amount was varied and in 2 conditions reinforcer delay was varied. In a fifth condition neither was varied. Lighting systems were the same as in Logue et al (1984 Experiment 1). That is, if a green key peck produced a reinforcer, then during the delay and reinforcer periods a green houselight came on and vice versa for the red key.

As a measure of self control Sa/Sd ratios were calculated using the slopes method. Fading-exposed subjects demonstrated a significantly higher sensitivity ratio than non-fading exposed subjects. This shows that the effects of a fading procedure can generalize to another schedule of reinforcement. In a fading procedure, subjects become relatively more sensitive to reinforcer amount than delay, as evidenced by an increase in Sa/Sd ratios. It appears that this change is due to a decrease of Sd, while Sa remains constant. In Logue et al (1984 Experiment 2), the median Sd for fading exposed pigeons was 0.7 compared to 1.5 for non-fading exposed pigeons. Median Sa values were similar for the two groups (1.4 for faded and 1.2 for non faded). So, fading procedures increase self control by increasing sensitivity ratios (due to a drop in Sd). This increase in sensitivity ratios can generalize to another schedule of reinforcement.

Generalization across Time

Logue and Mazur (1981) tested the stability of acquired self control 11 months after the completion of a fading procedure. The subjects were 3 pigeons which had previously acted as experimental animals for Mazur and Logue (1978). Again, a discrete trials procedure was used with a small reinforcer equal to 2s of grain and a large reinforcer equal to 6s. In the first condition the small delay was 0s as in the last fading step. Then, the overhead coloured lights, which corresponded to the colour of the key pecked, were removed during delay and reinforcement periods. In a third condition these coloured houselights were reinstated.

The results of this study showed no difference between Condition 1 here and the last condition from Mazur and Logue (1978). This indicates there was no difference in the number of large reinforcer choices over the 11 months between the 2 experiments. So, when the experimental procedures are identical, learned self control can generalize over time. However, in the third condition of Logue and Mazur (1981) when the coloured houselights were removed, the mean number of large reinforcer choices dropped from 19.5 to 7.2. Moreover, performance did not improve except for 1 bird when the lights were reinstated.

Logue and Mazur suggested that the houselights were acting as conditioned reinforcers and so limited the decrease in reinforcer value with increasing delay. A delay reduction hypothesis suggests that conditioned stimuli bridge the gaps between responses and delayed reinforcements. So a choice between 2 alternatives is affected by the conditioned reinforcers for each alternative. Since the value of a conditioned reinforcer decreases as the time to reinforcement decreases, then choice between the 2 alternatives depends on the delay to reinforcement of the 2 alternatives. However, contrary to this interpretation reinstating the coloured houselights (conditioned reinforcers) did not restore self control. The delay reduction hypothesis also fails to account for preference in terms of a subject's experience and so is not useful in describing the results of a fading procedure.

Generalisation of Self Control involving Delay and High Effort

An alternative definition of self control involves effort. Choosing to do a harder task for a larger reward instead of an easy task for a small reward can be seen as a self controlled response. Learned effort theory states that the amount of energy a subject expends on a task becomes conditioned to the stimulus situation. So, the generalization of learned effort depends on how similar the effort training and transfer situations are. This idea has been supported by research. For example, in a study by Eisenberger,Mitchell, McDermitt and Masterson (1984) learning disabled children were rewarded for either high reading accuracy or for high reading speed. Those rewarded for accuracy, later produced more accurate stories and drawings. Those rewarded for speed constructed stories more quickly. The generalization that occurred depended on the similarity between the learning and test situations.

Eisenberger and Adornetto (1986) ran an experiment to see if learned effort would generalize to self control situations involving delay and vice versa. To test this idea, baseline measures of self control involving delay and involving effort were taken before and after training. For the effort baseline, children chose between copying nonsense words for 3 s or waiting for an equivalent length of time for 2 cents. Baseline delay-type self control was measured by waiting until the end of the day for 3 cents or receiving 2 cents immediately. The subjects in this experiment were 88 second and third grade school pupils.

The training procedure involved 2 levels of effort crossed with absence or presence of a subsequent delay. The effort training tasks were object counting, picture memory and shape matching. The high effort tasks were designed to increase the effort required over sessions. So, for example, with picture memory, high effort groups were asked to remember up to 7 pictures whereas low effort groups were only asked to remember 1 picture. The delay manipulation involved the receipt of rewards earned in the effort training task. These rewards were given immediately or at the end of the day.

The results of this study suggest that self control involving delay and self control involving effort do not generalize to each other. Rewarded high effort led to greater self control involving effort than rewarded low effort at baseline, but did not affect self control involving delay. Experiencing the delayed reward led to greater self control involving delay at baseline than experiencing the immediate reward, but only when preceded by a low effort task. Experiencing delayed reward did not increase baseline self control involving effort.

The training situation for self control involving delay and the test situation for self control, both involved the same behaviour (ie waiting for a 3 cent reward at the end of the day or receiving 2 cents immediately). So this study showed that self control involving effort generalizes to another effort-based behaviour, but did not show that self control involving delay generalizes to other behaviours.

SUMMARY

The proportion of large reinforcer choices which an animal makes is dependent on the size of the reinforcer, and especially the duration of the delay before reinforcement. Individual differences in self control can be measured by the sensitivity exponents expressed in the matching law. Fading procedures can be responsible for creating individual differences in self control. These procedures decrease sensitivity to delay, which is otherwise usually greater than sensitivity to amount. Other manipulations which affect self control include deprivation , experience of long delays between reward and commitment.

The self control learnt in a fading procedure has been shown to generalize across time, and to other schedules. However this learnt increase in large reinforcer choices has not been shown to generalize to other behaviours. Despite this, self control theory has been applied to real life situations involving multiple behaviours.

The present study attempts to discover whether the self control which is learnt in a fading procedure will generalise to another choice situation. In order to study this, a multiple schedule was set up where two concurrent chains alternated. Each concurrent chain involved a choice between a smaller more immediate reinforcer and a larger but more delayed reinforcer. In one component this choice never altered. However, in the remaining component, the delay to the small reinforcer was increased in one step so that both reinforcers were equally delayed. Following this one step increase, the delay to the small reifnorcer was gradually decreased until the choice was once more between a smaller more immediate and a larger but nore delayed reinforcer,as in the initial condition. If self control does generalise from one situation to a similar situation, then the number of large reinforcer choices made in the non-fading component will increase when self control is taught in the fading component.

CHAPTER TWO

EXPERIMENT 1

METHOD

Introduction

Experiment 1 is a replication of a fading procedure within an operant self control paradigm. Previously this kind of experiment has been done using a discrete trials procedure (Mazur and Logue, 1978; Logue and Mazur 1984). The aim of Experiment 1 was to replicate the findings of Mazur and Logue (1978) using a concurrent chain procedure. Logue and Mazur (1984) found that a control group which experienced 3 sessions of each delay condition showed evidence of increased self control, although this learned self control was not maintained after a reversal condition where the contingencies associated with each of 2 keys were swapped over. In this experiment, subjects performed 5 sessions at each fading level, in an effort to ascertain how much training is required to produce a durable change in the numbers of larger reinforcers chosen.

The fading experiments referred to above, used an elaborate lighting system during the training procedure. A green houselight was illuminated during delay and reinforcement periods which were produced by pecking a green key. Pecking a red key led to the illumination of a red houselight during the resulting reinforcement and delay periods. In Experiment 1 this lighting system was not used. The left and right keys were both coloured green. A white hopper light came on during reinforcement periods. When delay periods occur all lights were blacked out.

A Stubbs and Pliskoff (1969) procedure was used to assign scheduled reinforcers in Experiments 1, 2and 3. Using this method, a single VI schedule arranges reinforcers which are assigned to each alternative with a .5 probability. An assigned reinforcer in one initial link must be received before further reinforcers can be programmed.

This non-independent scheduling ensures that the obtained relative reinforcer frequency equals the programmed relative reinforcer frequency. This prevents the formation of a feedback relation beween preference and relative rate of reinforcement.

Chavarro and Logue (1988) investigated the use of non-independent scheduling in a self control paradigm. Preferences were more exteme using independent rather than non-independent scheduling, but not significantly so. Sa and Sd values were smaller using non-independent scheduling, but the ratio of Sa/Sd was unchanged. Hence, a Stubbs and Pliskoff procedure is an effective way of ensuring that obtained and programmed reinforcement rates are similar without affecting reliable measures of performance. This also eliminates the need for forced choice trials as in Mazur and Logue (1978) as subjects are aware of the contingencies associated with both keys.

Subjects

The subjects were 4 pigeons identified as A1-A4. These pigeons were maintained at 80% +/- 3% of free feeding body weights, by additional feeding at the end of each training sessions when necessary. Water and grit were available ad lib in home cages.

Apparatus

The experiment was performed in 4 pigeon chambers which measured 36cm long, by 32cm wide by 35 cm high. This chamber contained 3 reponse keys at a height of 23.5 cm. These keys could be illuminated green or red. Only the left and middle keys were used in Experiments1, 2 and 3. The left key was 8cm from the left side of the chamber. The middle key was 16cm away from either side. Pecking a response key produced a feedback click from a relay, and momentary offset of the lamp behind the key..

A houselight gave white illumination. Ventilation and masking noise were both provided by extractor fans. A MED-PC program controlled the stimuli and recorded responses.

Procedure

The basis of this experiment is a concurent chain. The terminal links were fixed -time (FT) schedules of varying length (ie consisted of delays of varying duration). The initial link was made up of two concurrent VI 30s schedules. Left and centre response keys were illuminated green during the initial link. During the terminal link, the pre-reinforcer delay occurred in blackout conditions and reinforcers were presented with only a hopper light operating. Post reinforcer delay durations were set to equate the length of the two terminal links at13s.

The pre-reinforcer delay in this study consisted of a floating delay which varied from reinforcer to reinforcer, plus a fixed delay. The floating delay was either 0, 0.1 or 0.5s therefore was equal to 0.2s on average. So an 8s delay was made up of the 0.2s average delay plus 7.8s. It was thought that the use of a floating delay may enable the fading procedure to be performed more quickly. Each session consisted of 42 reinforcement cycles. Sessions were conducted 7 days per week. Reinforcers are described as duration of grain access in seconds.

There were 3 parts to this experiment which are summarized in Table 1: a baseline, a fading procedure which terminated with a second baseline, and a reversal condition in which contingencies associated with left and centre keys were reversed. All subjects participated in all 3 conditions. In the baseline, the terminal links were FT-8s and FT-0.3s. The reinforcer durations were 4.5s and 2.5s respectively, i.e. the larger reinforcer is associated with the longer delay duration. So, the subjects chose between a 4.5s reinforcer delayed by 8s or a 2.5s reinforcer delayed by 0.2s. The large later reinforcer was produced by pecking the right key and left key pecks produced the smaller earlier reinforcer.

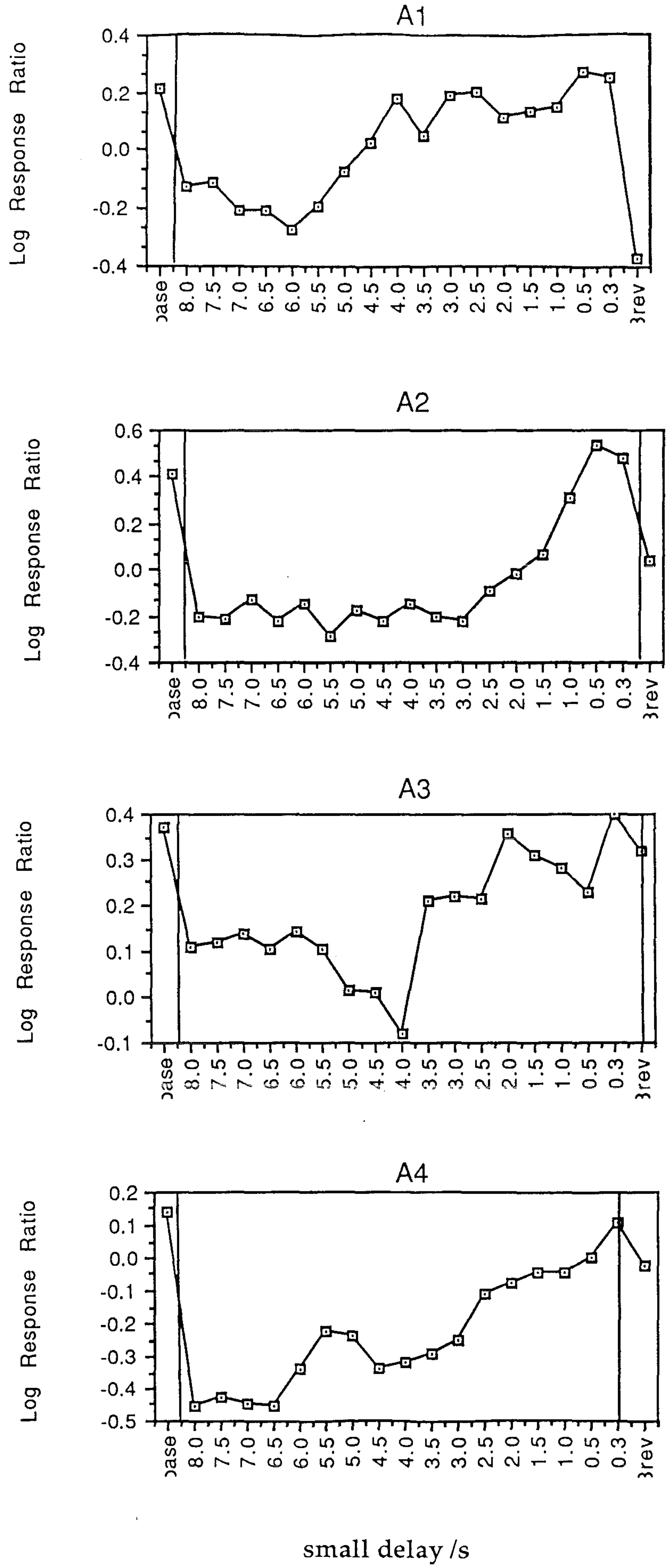
During the fading procedure, the delay to the small reinforcer was increased to 8.0s and then decreased in 0.5s increments every 5 sessions. The baseline condition was then run again, followed by a reversal condition where the contingencies associated with each of the two keys were swapped over. The choice here was again a choice between large delayed versus small immediate reinforcers, but each option was now associated with a different key.

Table 1

Order of Conditions in Experiment 1

Delay 1 (A=2.5)	Delay 2 (A=4)	Sessions
0.2	8.0	32
8.0	8.0	21
7.5	8.0	3
7.0	8.0	5
6.5	8.0	5
6.0	8.0	5
5.5	8.0	5
5.0	8.0	5
4.5	8.0	6
4.0	8.0	5
3.5	8.0	5
3.0	8.0	5
2.5	8.0	5
2.0	8.0	6
1.5	8.0	5
1.0	8.0	5
0.5	8.0	5
0.2	8.0	9
0.2 (reversal)	8.0	

Figure 4. Log Response Ratios for the Small Reinforcers in Experiment One.



RESULTS

Figure 4 shows the log response ratios for each pigeon, averaged over the last 5 sessions in each condition. The log response ratio is calculated as follows: log (B_S/B_L). B refers to the number of responses made for the small (S) or large (L) reinforcer. Figure 4 presents the log response ratios for A1-A4. A positive log response ratio indicates a preference for the small reinforcer.

The transition from the baseline to the first fading step where both reinforcers were delayed by 8s led to a large drop in small reinforcer choices for all subjects. Small reinforcer choices did not increase until the small delay ranged from 6s (A4) to 2.5s (A2). After the first rise in small reinforcer choices, log response ratios increased as the small delay was decreased until responding was similar to baseline levels. In fact when baseline conditions were reached, A1, A2 and A3 were slightly more impulsive than before the fading procedure. Only A4 shows increased large reinforcer choices when the first baseline (small delay=0.2) and the final fading step are compared. This difference was very small, the log response ratios were 0.143 for the first baseline and 0.107 for the last fading step.

During the reversal condition, all birds showed a decrease in small reinforcer choices (i.e. an increase in self control)which were formerly associated with the key which delivered the large delayed reinforcer.

DISCUSSION

A fading procedure usually increases preference for the larger more delayed reinforcer. In other words, subjects become more self controlled. Mazur and Logue (1978) found that their subjects excusively chose the large reinforcer when the small reinforcer was delayed by 3.25s or longer. At the end of the fading procedure, the large reinforcer was chosen 55.9% of the time by an experimental group and 2.5% by a control group. This increase in large reinforcer choices after a fading procedure was also found by Logue et al (1984).

In Experiment 1, A1-A4 initially responded as expected. All subjects chose the large reinforcer more frequently when the small reinforcer delay was increased to 8s. This difference was maintained for varying amounts of time. In Mazur and Logue (1978) this pattern of responding also occurred. When the small reinforcer delay was 3.25s of longer, all subjects showed a strong preference for the large reinforcer. After this plateau, subjects in Mazur and Logue (1978) gradually increased choices of the small reinforcer, but never to the same extent as the control group, which did not participate in a fading procedure.

In Experiment 1, after the plateau, small reinforcer choices rose until for 3 pigeons, log response ratios were slightly higher than in the pre-fading baseline. Obviously, there was no increase in self control.

Previous fading procedures performed each delay step for a longer period of time dependent on reaching stability criterion. In Mazur and Logue (1978), the number of sessions per step varied from 12 to 38. Logue et al (1984) performed each step from 10 to 54 times for the 2 experimental groups. However, Logue et al (1984) also ran a control condition where their pigeon subjects were exposed to only 3 sessions of each condition. Interestingly, the control group made as many large reinforcer choices as the experimental group in the final step of the fading procedure. However, when the contingencies for the left and right keys were reversed, the experimental groups maintained their learned self control, whereas the control group did not. Logue et al (1984) suggest that 3 sessions per condition was not enough to increase self control. The increase shown was explained as a position bias which caused the increase in self control to vanish during the reversal condition.

In Experiment1, 2 subjects showed large changes in preference during the reversal condition. The changes were an increase in large reinforcer choices. This increase is most likely a position bias as during the reversal, the large reinforcer is associated with the left key, which was formerly associated with the small reinforcer. The control group of the Logue et al (1984) study, showed a response bias for the key which delivered the larger reinforcer. In the present study the reverse occurred.

The fading procedure in Experiment 1 did not increase self control and this was probably due to running each fading step for only 5 sessions.

Procedural Differences

There were several procedural differences between Experiment 1 and Mazur and Logue (1978) and Logue et al (1984). Experiment 1 scheduled reinforcers non-independently. Scheduling reinforcers in this way has been show to decrease Sa and Sd values but the ratio of Sa/Sd remains the same (Chavarro and Logue, 1988). The ratio of Sa/Sd is a more stable way of measuring sensitivity change and so non-independent scheduling is an unlikely explanation of differences between fading procedures.

Another difference is the lighting used during delay and reinforcerment periods. In Experiment 1, all delay periods occurred in blackout, and reinforcement periods were illuminated only by a hopper light. Mazur and Logue (1978) used a more complex lighting system. This issue will be examined in Experiment 2.

The procedures used in Experiment1 and in Mazur and Logue (1978) both involve concurrent chains. In Experiment 1 VI 30s initial links led to a terminal link. The delays and amounts used in this terminal link were presented in Table 1. Preference is measured by the responses made on the 2 keys with which the 2 delays are associated. Mazur and Logue (1978) however used a discrete trials procedure where a choice trial was presented every minute. Preference was measured by the number of large reinforcer choices made. The measure of preference used in Experiment 1 is likely to be more sensitive as it is not an all or none measure like the preference measure used by Mazur and Logue (1978). However, the difference between these 2 procedures should be a question of degree only, and does not account for the lack of self control developed in Experiment 1.

CHAPTER THREE

EXPERIMENT 2

METHOD

Introduction

Experiment 2 was an attempt to achieve an adequate baseline in a multiple concurrent schedule, so that a fading procedure could be carried out in 1 of 2 components.

In Experiment 2, a multiple schedule arrangement was used in which 2 concurrent schedules alternated in a multiple schedule. In Component 1 of this multiple schedule, the left key delivered the small reinforcer and the right key delivered the large reinforcer. In Component 2 the left key delivered the large reinforcer and the right key delivered the small reinforcer. In other words, Component 1 is a replica of the baseline condition in Experiment 1. In Component 2 the keys associated with the small and large reinforcers were reversed.

The log response ratio is the log of (B_S/B_L), where B equals the number of pecks made during the initial link on the key associated with either the small (S) or the large (L) reinforcer. In the baseline of Experiment 1, the log response ratio was averaged over 4 subjects and over the last 5 sessions and was equal to 0.283. In the initial baseline of Experiment 2, a similarly averaged log response ratio equalled 0.123, indicating that these subjects were behaving in a much less impulsive manner (i.e. choosing a lower proportion of small reinforcers) than A1-A4 in Experiment 1. In order to significantly increase self control in a fading procedure, it is necessary that the subjects are not self controlled to start with.

Hence, the planned fading procedure was postponed and in the rest of Experiment 2 several variables were manipulated in an effort to gain more extreme baseline impulsiveness. Experiment 2 involves the manipulation of several variables which have been shown to affect self control. The variables that were changed include: the length of the initial link, body weight, the presence of houselights signalling either the large or small reinforcer and the length of the change-over delay (COD).

The fading procedure was postponed after discussions with Prof. K. Geoffrey White who indicated that the preferences (for the small reinforcer) which were observed in Experiment 2 were smaller than those which could normally be expected.

Length of Initial Link.

Research into concurrent chains has shown that sensitivity to the terminal link reinforcer ratio decreases as the relative duration of the initial link increases (Davison 1987). In Experiment 2, the initial link was shortened by decreasing the value of the schedule in the initial link. So, access to the terminal link was faster. In a shortened initial link, sensitivity to the terminal link contingencies should be increased. If the length of the initial link is compared to a preference reversal situation, shortening the initial link should also increase small reinfocer preference. The further away in time an organism is from two choices , the more likely it is to choose the larger reinforcer. Hence, shortening the initial link should increase preference for the small reinforcer.

Body Weight

Eisenberger et al (1982) and Snyderman (1983) both found that food deprivation increased impulsiveness. In Experiment 2, deprivation level was reduced from 80% to 75% of free feeding weights in an attempt to increase preference for the small reinforcer.

COD Length

A COD is used to prevent the development of superstitious responding between the two response alternatives. A COD states that a certain period of time must elapse between changing response keys and receiving a reinforcer from the key the subject switched to.

King and Logue (1987) found that increasing the COD duration, increased choices of a larger more delayed reinforcer in adult humans. COD duration was either 1, 15 or 30s. Subjects chose between 2 alternatives which differed in amount and delay, at each COD duration. As the length of the COD increased, preference changed from indifference between the large and small reinforcers to near exclusive preference for the large reinforcer. A corresponding change in Sa values occurred. As COD duration increased, Sa values increased from a mean of 0.78 (COD=1s) to 2.99 (COD=30s). Sd values decreased slightly. Statistical analysis showed the Sd effect to be significant but not the Sa effect due to large individual differences. Hence, an increased of COD duration led to greater preference for a larger later reinforcer as sensitivity to delay of reinforcement decreased.

In Experiment 2, COD duration was decreased from 3s to 0.5s. This should have increased choices of the small reinforcer.

Signalling Large or Small Reinforcers

Rachlin (1974) recommends increasing the salience of delayed rewards as a way of increasing the number of larger later reinforcers chosen. Logue and Mazur (1981) suggest that the delay lights in their study acted as conditioned reinforcers. If this is accurate, adding a conditioned reinforcer to only one alternative (eg. to the smaller earlier reinforcer) will increase the choices for that alternative.

The suggestions of Rachlin (1974) and Logue and Mazur (1981) make the same predictions. Accordingly, in Condition 8 of Experiment 2, a houselight was left on during the delay before the large reinforcer. From Condition 9 onwards, a houselight was illuminated only during the delay before the smaller reinforcer. Adding a houselight during the short reinforcer delays should increase impulsive behaviour.

Subjects

The subjects were 4 pigeons identified as C1-C4. Housing and feeding arrangements were the same as in Experiment 1.

Apparatus

The apparatus is as described in Experiment 1.

Procedure

The basic procedure for this experiment is as in Experiment 1. The major difference was that two concurrent chains alternated in a multiple schedule. Component 1 was signalled by green response keys and Component 2 was signalled by red response keys. Component 1 was thus identical to Experiment 1.

In Component 1, the small reinforcer (2.5s) was accessed by pecking the left key. Pecking the right key produced the large, 4.5s reinforcer. In Component 2, the small and large reinforcers were associated with the opposite response keys to control for position bias.

The conditions and number of sessions per condition are given in

Table 2. For Conditions 4-6, the pigeons were kept at 75%+/-3% of free feeding body weights. From Condition 7 onwards, the weights were maintained at 80%+/- 3% of free feeding body weights. The COD duration was reduced from 3s to 0.5s and Components 1 and 2 were strictly alternated. Prior to Condition 7, components followed each other randomly, with the restriction that there were no more than 3 consecutive cycles with the same component.

Each condition was ended after a minimum of 10 sessions, provided that Impulsiveness values showed neither an upward nor downward trend for 5 sessions. Impulsiveness was measured using the difference between log ratios in Components 1 and 2:

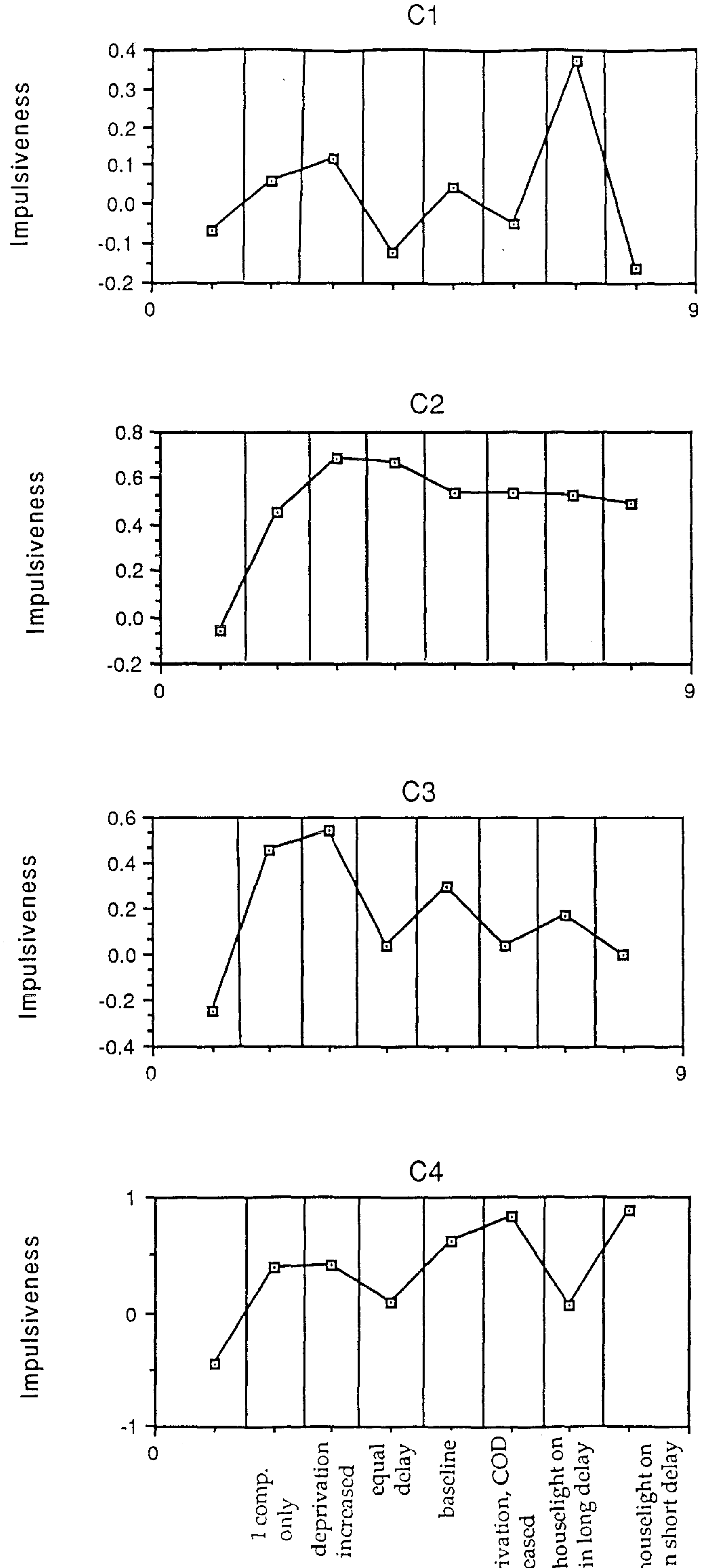
$$\text{Impulsiveness} = \log(B_{L1}/B_{R1}) - \log(B_{L2}/B_{R2}) \qquad \text{Equation 7}$$

In the equation above, B measures the number of responses made on the left side (L) or right (R), and in Component 1 or 2. Measuring impulsiveness in this way, eliminates any position preferences which might affect the measures of preference for the small immediate reinforcers. For the case where Component 1 left key responses and Component 2 right key responses both produce the small immediate reinforcer, large values indicate high impulsiveness.

Table 2
Order of Conditions in Experiment 2

Condition	Component 1 A_1 D_1 A_2 D_2	Component 2 A_1 D_1 A_2 D_2	Number of Sessions
1. Component 1 only Weight=80% VI 30s	2.5 0.5 4.5 8		
2. Component 2 only VI 30s		4.5 8 2.5 0.5	18
3. Components 1 and 2 alternated VI 30s VI 30s	2.5 0.5 4.5 8	4.5 8 2.5 0.5	25
4. Weight=75% 42 cycles	2.5 0.5 4.5 8	4.5 8 2.5 0.5	16
5. Equal delays			
C1 and C2	2.5 0.2 4.5 8	4.5 8 2.5 8	14
14			
C3 and C4	2.5 8 4.5 8	4.5 8 2.5 0.2	14
6. Baseline			
7. Weight=80% COD=0.5s Strict Alternation	2.5 0.2 4.5 8	4.5 8 2.5 0.2	14
8. Houselight on in long delay	2.5 0.2 4.5 8	4.5 8 2.5 0.2	14
9. Houselight on in short delay	2.5 0.2 4.5 8	4.5 8 2.5 0.2	28

Figure 5. Impulsiveness values in Experiment 2.



Results

Figure 5 plots Impulsiveness for each of the various manipulations of Experiment 2. The aim of this experiment was to increase the difference between the log response ratios of Component 1 and Component 2 (i.e. to increase the impulsiveness measure as the large and small reinforcers were associated with opposite keys in Compomnent 1 and Component 2).

The first panel of Figure 5 shows the effects of running each component separately. All four pigeons showed an increase in Impulsiveness. The effect of increasing deprivation is smaller. Three subjects produced small increases in Impulsiveness. C4 was unchanged.

In the equal delay condition, the delay to the small reinforcer was increased to 8s, in one of the 2 components. This occurred in Component 2 for C1 and C2 and in Component 1 for C3 and C4. Impulsiveness values returned to pre-equal delay levels, only for C4.

Decreasing the level of deprivation and the COD duration, did not have a clear effect. Two birds showed a small decrease and one bird showed a small increase in Impulsiveness values. The houselight manipulation had clear, opposite effects for 3 birds. C1 and C3 increased Impulsiveness values when the long delay was signalled, and decreased Impulsiveness when the short delay was signalled. C4 however, decreased Impulsiveness values when the houselight was associated with the long delay and increased Impulsiveness values when the houselight came on during the short delay.

Summary

Running each component separately increased Impulsiveness values more than the other conditions. After food deprivation was increased, C1, C2 and C3 all showed higher Impulsiveness values than in the final condition.

Discussion

The aim of Experiment 2 was to acheive large Impulsiveness values. A large Impulsiveness value reflects a large difference in log response ratios between the two components. This indicates that the subjects are choosing the small immediate reinforcers in both components most often, not just choosing one of the keys in preference to the other.

The most effective manipulation in Experiment 2 was running both components separately. Presumably, this enabled the subjects to discriminate between the 2 components more accurately and to learn the separate contingencies. With alternating components, increasing the level of deprivation increased Impulsiveness values for 3 out of 4 subjects.

Eisenberger et al (1982) and Snyderman (1983) both found that increasing levels of food deprivation led to an increased number of small reinforcer choices, provided that the difference in delays is large enough. In this experiment increasing food deprivation increased Impulsiveness values for 3 out of 4 subjects. This finding indicates that subjects chose more small reinforcers in both components and hence supports both Eisenberger et al (1982) and Snyderman (1983). Logue and Pena Correal (1985) found that preference was not affected by food deprivation. Experiment 2 does not support this finding, however, the change in preference found in Experiment 2 was not large.

Following the deprivation condition (Panel 2 of Figure 5), the small reinforcer delays in one component were increased to 8s (ie were equal to the large reinforcer delays). This is the first step of a fading procedure. However, the resulting change in preference was seen to be too small. Mazur and Logue (1978) and Logue et al (1984) both found that all pigeons chose the large reinforcer on over 90% of all trials, when the delays before the small and large reinforcer were equal. So all subjects were returned to baseline.

Eisenberger et al (1982) found that experiencing long delays between rewards (a FR80 schedule) led to greater subsequent self control than experiencing short delays between rewards. In Experiment 2, Impulsiveness values in the baseline after the equal delay condition were not the same as in the baseline before the equal delay condition. Two subjects (C3 and C1) had lower Impulsiveness values in the baseline condition. One bird produced slightly higher Impulsiveness values in the baseline and one bird stayed the same. If C3 and C1 had lower Impulsiveness values due to an increased preference for the large reinforcer after the equal delay condition, then this would support Eisenberger et al (1982). In the post equal delay baseline, C1, C2 and C3 all showed greater preference for the large reinforcer in the component which was altered for the equal delay condition, than in the pre-equal delay baseline. This difference was small but is still in the direction predicted by Eisenberger et al (1982). So, experience of long delays between rewards can lead to greater preference for the large reinforcer but the amount of training required to produce a large change is not investigated by this study.

Responding in the baseline condition was not as impulsive as in previous studies. Mazur and Logue (1978) ran a control condition where 4 pigeons were exposed to a choice between a 6s reinforcer delayed by 6s and an immediate 2s reinforcer. On average, subjects chose the small reinforcer on more than 97% of trials. However Tapp (1990) reports opposite findings. In the initial condition of Tapp's study, pigeons chose between 2s grain access delayed by 4s and 6s grain delayed by 8s. The mean proportion of larger reinforcer choices was approximately 0.62. So, there seems to be a large amount of variation in levels of impulsiveness between different studies.

After the subjects in Experiment 2 had been returned to baseline, several alterations were made simultaneously, to avoid disruption of responding and also because of time factors. Although the increased deprivation condition had been successful in increasing Impulsiveness values, body weights were returned to 80% as 75% deprivation seemed too harsh to be maintained throughout the length of a fading procedure. The other changes introduced at this stage were: reducing the COD to 0.5s, strict alternation of components and reducing the average floating delay to 0.2s.

As all these changes occurred at once, no conclusions can be drawn on the individual effects of each manipulation. However, Impulsivness values dropped for 2 pigeons, and increased for 1 pigeon. This drop in Impulsiveness could be due entirely to the decrease in deprivation as increasing deprivation had the opposite effect. It was thought that decreasing the average floating delay to 0.2s would have significantly increased small reinforcer choices. The immediacy of delay has been shown to be very important,in that discount functions show how a preference for a large reinforcer reverses when the small reinforcer becomes nearer in time. However small reinforcer choices were not increased.

Presence of Houselights

Illuminating a houselight during the long delay led to a large increase in Impulsiveness for one pigeon and decreases for 2 other pigeons. Illuminating a houselight during the short delay reversed these changes. Because of these contrary results no clear statement can be made. Logue and Mazur (1981) suggested that the delay lights in their study were acting as conditioned reinforcers.

This idea was investigated by Lopatto and Lewis (1985) and by Lewis and Lopatto (1989). When a signal light is followed by grain presentation, the signal may begin to elicit key pecks regardless of the consequences of pecking the key. From a Pavlovian viewpoint, a signal paired with grain presentation may become a conditioned stimulus which elicits pecking (the conditioned response). So the signal-controlled pecks can account for some of the responding attributed to a reinforcer. Lopatto and Lewis (1985) used a 1 key procedure with 2 conditions. In a 2 reinforcer condition, pigeons could peck a key after a 4s signal and receive a 2s reinforcer immediately, or could make no response and receive a 4s reinforcer after a 4s delay. In an omission condition, subjects chose between pecking and receiving no reinforcer or not pecking and receiving the large delayed reinforcer. These 2 conditions were alternated in an A B A B design. The frequency of pecking was high (90% of 2 reinforcer trials and 70% of omission trials). This suggests that the frequency of pecking was affected by the keylight-reinforcer association.

Lewis and Lopatto (1989) repeated this experiment, but this time pecking produced the large reinforcer and not pecking produced the small reinforcer or the omission procedure, depending on the condition operating at that time. The duration of the large reinforcer delay in this study ranged from 6 to 80s. When the delay before the large reinforcer changed from 6 to 80s, the frequency of pecking changed from 81.9% to 60%.

Comparing these 2 studies reveals that the programmed consequences for pecking were not as important as the strength of the elicited pecking. This finding can have implications for self-control studies. Ainslie (1974) studied commitment using a procedure where pigeons pecked a key during a 3s signal and recieved 2s grain access or did not peck and received a 4s reinforcer delayed by 4s. The subjects in this study chose not to peck on only 5% of trials. This study was seen as evidence of the impulsive nature of pigeons, but Lopatto and Lewis (1989) suggest that an elicition process is obscuring the effectiveness of the programmed reinforcers.

If this conclusion is applied to Experiment 2, all subjects should have become more self controlled when the houselight was present during the long delay (Impulsiveness should decrease) and more impulsive when the short delay was signalled (Impulsiveness increases). This did not happen. An interesting question may be if signal lights effect behaviour differently to blackout periods. In Experiment 2 all delays were carried out in blackout, except for the 2 houselight conditions.

Rachlin (1974) suggests that paying attention to the large reinforcer increases self control. In Experiment 2, adding a houselight during the delay to the large reinforcer, increased self control for 2 pigeons but produced a large decrease in self control for another pigeon. Mischel et al (1972) demonstrated that children will wait longer to receive a larger reward when distracted from the reward. So, adding a houselight during large reinforcer delays would decrease self control. Unfortunately, the results of Experiment 2 are contradictory on this point. Perhaps the conclusion which can be drawn concerns the individual diffences among pigeons in self control studies.

CHAPTER FOUR

EXPERIMENT 3

METHOD

Introduction

Experiment 1 replicated a fading procedure using a single component. Experiment 2 established a baseline using 2 components, where each component is a choice between a smaller earlier and a larger later reinforcer. Responding in these components was, barely sufficiently impulsive to allow a fading procedure to be performed in one component.

Applications of self control research have indicated that self control is a generalised phenomenon. For example, Wilson and Herrnstein (1985) describe a criminal population as impulsive. However, research has suggested that self control only generalizes to similar situations and behaviours. In Experiment 3, self control will be taught in one component of the multiple schedule. The aim of this experiment is to discover whether the self control learned in one component will generalise to another component.

Subjects

The pigeons used in this study were C1-4. These pigeons were also used in Experiment 2. The weights of C1-4 were maintained at 80%+/- 3% of free feeding body weights.

Apparatus

The apparatus was as described in Experiment 2.

Procedure

Two concurrent-chain schedules, each with VI 30s initial links were strictly alternated in a multiple schedule. The amounts (A) and delays (D) used in the terminal links are given in Table Y. Reinforcer amounts are described by duration of grain access in seconds. The left and right response keys in the initial link were illuminated by green light in Component 1 and by red light in Component 2. When a large reinforcer was assigned, all lights were turned off during the delay and reinforcement periods. When a small reinforcer was assigned, a white houselight was illuminated during delay and reinforcement periods. In both cases a feeder light came on when the feeder was in operation. The COD was set at 0.5s.

The fading procedure was carried out in Component 2 for pigeons C1 and C2 and in Component 1 for C3 and C4. The delays and amounts in the non fading components remained unchanged over Conditions 1-3.

Table 3 gives the order of conditions and the number of sessions each condition was run for, with one exception. In the fading condition the delays which were faded are underlined. These delays were reduced in steps of half a second from 8s to 0.5s. Each step in the fading condition was run for 7 sessions.

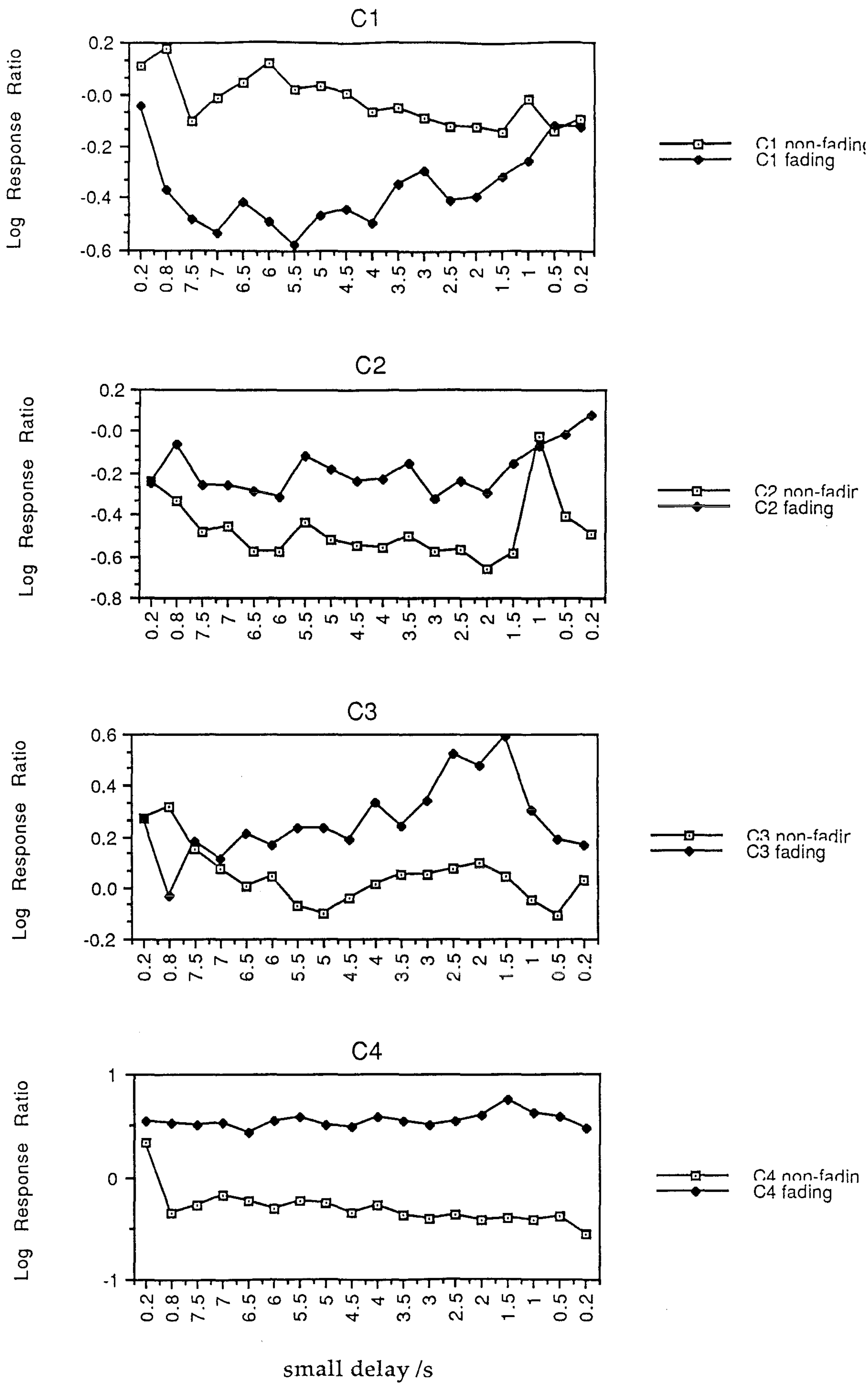
Table 3
Order of Conditions in Experiment 3

Condition of	Component 1 A1 D1 A2 D2	Component 2 A1 D1 A2 D2	Number Sessions
1. Equal delays			
C1 & C2	2.5 0.2 4.5 8	4.5 8 2.5 8	21
C3 & C4	2.5 8 4.5 8	4.5 8 2.5 0.2	21
2. Fading			
C1&C2	2.5 0.2 4.5 8	4.5 8 2.5 7.5	7/step
C3&C4	2.5 7.5 4.5 8	4.5 8 2.5 0.2	7/step
3. Baseline			
C1-C4	2.5 0.2 4.5 8	4.5 8 2.5 0.2	10

Results

Figure 6 presents log response ratios, averaged over the last 5 sessions of each condition in Experiment 3. In the non-fading component,

Figure 6. Log response ratios in Experiment Three.



the response ratios were calculated by dividing responses on the large reinforcer key by responses on the small reinforcer key. Thus for unfilled squares in Figure 6, positive log response ratios represent preference for large reinforcers (i.e., self control). For the fading component small reinforcer key pecks were divided by large reinforcer key pecks. So, for the filled diamonds, positive log response ratios represent preference for small reinforcers (i.e. impulsiveness).

Performance in the Fading Component

In the baseline condition, high positive log response ratios were expected, indicating a preference for the small reinforcer. Two birds showed positive log response ratios, indicating a preference for the small reinforcer. Of the remaining two birds, one gave a log response ratio close to 0 and the other gave a negative log response ratio, indicating a preference for the large reinforcer.

When delays to the small reinforcer were increased to equal those for the large reinforcer in one component, the log response ratios for two out of the four birds dropped suddenly, indicating an increase in large reinforcer choices. This was expected as the birds were now choosing between a large and a small reinforcer, delayed by an equal amount. However, of the two remaining birds, one showed no change at all and one showed an increase (i.e. was more self-controlled).

Effects of Fading

Following the condition where both reinforcers were equally delayed in one component, the delays to the small reinforcer in that component were gradually reduced in half second steps. During this progressive reduction in delay, log response ratios gradually increased throughout the fading procedure, increasing more rapidly as the faded delay came closer to 0.2. This increase represents an increased preference for the small reinforcer.

By the last step of the fading procedure, conditions were identical to those in the initial baseline. Comparing the results of these two conditions shows clearly that the fading procedure did not significantly increase large reinforcer choices. Two birds (C1and C3) showed an increase in large reinforcer choices, but this was a very small change. One bird (C2) showed an increase in small reinforcer choices, whilst performance for the remaining bird (C4) showed little change throughout the whole experiment.

Performance in the Non-Fading Component

Performance in the non-fading component was intended to study possible generalization of self control acquired in the fading component. This would appear as progressive increases in preference for the large reinforcer in the non-faded component. However, it is clear that, if anything, the reverse was the case. All four subjects showed a decrease in log response ratios in the non-fading component over the course of the fading procedure. This signifies an increase in preference for the small reinforcer (i.e. increased impulsiveness, not increased self control).

DISCUSSION

Fading Component

As in Experiment1, the fading procedure did not lead to significant increases in self control when the first and last 0.3s conditions are compared. Only two birds (C1 and C3) showed any increase in self control but this was slight. C1 is the only pigeon to show the typical pattern of responding normally found in a fading procedure (see Figure 7). Mazur and Logue (1978), Logue et al (1984) and A1-A4 in Experiment 1 all show a pattern of responding during the fading procedure where a high preference for the large reinforcer remains constant for some time. This occurred at a range of 6 to 2.5s in A1-A4. Another difference between Experiment 1 and 3 lies in the change in preference when the initial baseline is changed to an equal delay condition where the small reinforcer is delayed by 8.0s. In Experiment 1 this change produced a marked increase in preference for the large reinforcer. In Experiment 3, only small increases in large reinforcer preferences were found.

Non-Fading Component: Generalisation

As there was no increase in self control in the fading component, no generalisation of learnt self control to the non-fading component could occur. As Figure 6 shows, all subjects decreased their choices of the large reinforcer over the course of the fading procedure. This change in preference may reflect any confusion which subjects may have had regarding the reinforcement schedules in Experiment 3. The two alternating concurrent schedules were signalled by green keylights in Component 1 and red keylights in Component 2. However, if the birds had difficulty distinguishing between the two schedules, the results of Experiment 3 can be explained.

Firstly , the absence of response patterns typical of fading procedures could be because the subjects were unclear which schedule they were in. Secondly, the consistent decrease in large reinforcer choices in the non-fading component could reflect a position bias which developed in the fading component. The large reinforcer in the non-fading component is associated with the same key as the small reinforcer in the fading component. So perhaps there was a decrease in small reinforcer choices (an increase in self control) but this is masked by the subjects confusion regarding the multiple, concurrent reinforcement schedule.

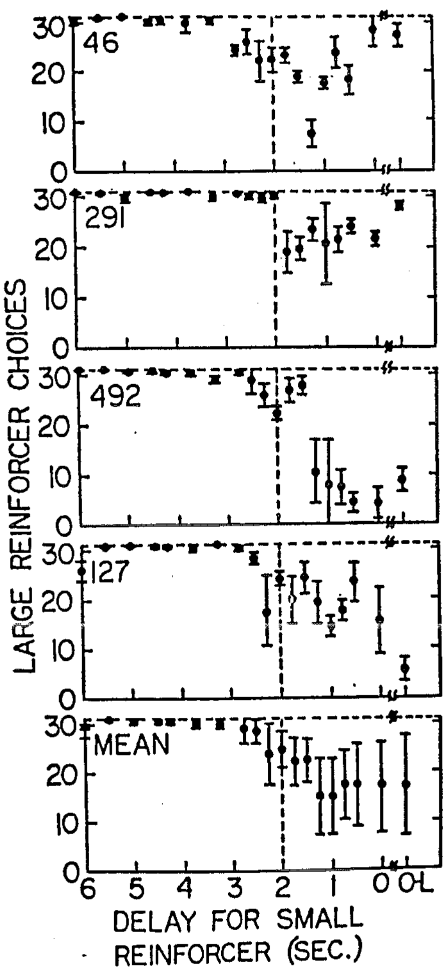


Figure 7 plots the mean number of large reinforcer choices in the last five sessions of each condition of the fading procedure from Mazur and Logue (1978). This figure shows a pattern of responding which is characteristic of a fading procedure.

CHAPTER FIVE

GENERAL DISCUSSION

Self control has been studied in the laboratory from an operant behavioural perspective, where a self controlled response can be depicted as choosing a larger more delayed reinforcer instead of a smaller more immediated reinforcer, when the two rates of reinforcement are equal. The generalized matching law has been used to describe this kind of behaviour.

$$B_1/B_2 = k(A_1/A_2)^{Sa} . (D_2/D_1)^{Sd} \qquad \text{Equation 8}$$

where B1and B2 refer to the number of responses made for each of 2 alternative reinforcers and A1 and A2, and D1 and D2 refer to the amounts and delays associated with each of these reinforcers, respectively. k is a constant which measures response bias whilst Sa and Sd represent a subject's sensitivity to changes in the size and delay of a reinforcer. The matching law predicts that a subject will choose Alternative 1 when A1.D2 > A2.D1 and will reverse preference to choose Alternative 2 when A1.D2 < A2.D1.

One area of study in the literature has concerned a difference in responding between animal and human subjects. Animals have been described as impulsive. This can be illustrated by the first condition of Ainslie and Herrnstein's (1981) study where pigeons initially chose between 2s of grain delayed by 0.01s and 4s of grain delayed by 4.01s. The mean preference for the larger, later reinforcer was less than 0.1. Contrary to this, humans have been described as exhibiting self-control. For example, Logue et al (1986) found that the female students in their study showed more self control than predicted by the matching law. However, this study used a conditioned reinforcer where subjects were given points which could be exchanged for money at the end of a session. This type of reinforcer cannot be equated with the food reinforcer used in animal research as food is instantly consumed whereas conditioned reinforcement involves some delay.

Other studies which have used primary reinforcers with human subjects have found impulsive responding. For instance, Navarick (1982) used negative reinforcement in the form of termination of an unpleasant noise. So, impulsiveness has been observed in both human and animal subjects when primary reinforcement is used.

Differences in self control have been found not only between different species and procedures but also within experiments. For example, Ainslie (1974) investigated commitment in pigeons. In his efforts to demonstrate commitment, Ainslie found it necessary to screen potential subjects in order to find those that learned pre-commitment. Of these 10 carefully selected sujects, only 3 pigeons learned the commitment response. In this experiment, the commitment response involved pecking a green key and receiving a 4s reinforcer, rather than waiting until the key was red and pecking to recieve 2s food immediately or not pecking and receiving 4s of food after a 3s delay.

So, individual differences in self control exist and in the laboratory, procedures have been developed which influence the level of self control which subjects exhibit. These procedures have been effective with both human and animal subjects.

Ferster (1953) first suggested that the way an organism is introduced to a delay affects the way the organism responds to it. In a fading procedure, the delay associated with one of the two reinforcers is gradually changed in some way. A good example of this procedure is provided by Mazur and Logue (1978). Mazur and Logue initially gave pigeons in an experimental group a choice between a 2s reinforcer and a 6s reinforcer both delayed by 6s, then gradually reduced the delay to the small reinforcer until the choice was between a small immediate and a large delayed reinforcer.

The experimental group chose significantly more large reinforcers in the final choice, than a control group which did not experience the fading procedure, that is, the experimental group were more self-controlled. The generalized matching law accounts for this change in preference by an increase in the Sa/Sd ratio. This indicates that exposure to a fading procedure makes a subject relatively more sensitive to reinforcer amount ratios than to reinforcer delay ratios.

Fading procedures have also been successfully carried out with rats and children, reinforcing Fersters assertion that the way a subject is introduced to a delay is important. In the natural environment, people also show large differences in self control, which may be due to the delay and reward contingencies they have experienced. Eisenberger et al's (1982) research suggests that just experiencing long delays is an effective way of increasing large reinforcer choices, without a fading procedure.

Another factor which has been shown to affect self control is deprivation. Eisenberger et al (1982) concluded that food deprivation increases preference for a small immediate reinforcer over a larger more delayed reinforcer, provided that a sufficiently large difference in delay is used. In Eisenberger et al's study, high hunger groups performed trials 20-22 hours after daily feeding, and showed increased impulsiveness when choosing between 1 food pellet delayed 1s and 7 pellets delayed by 32s.

When self control has been learned in a particular behaviour and situation, does this generalize to another behaviour or situation? For example, does a person find it easier to control a weight problem after having successfully quit smoking. Theorists in the area of self control have assumed that this is true. In other words they have assumed that self control easily generalizes to other behaviours and situations. So, a person would be self-controlled in most of their behaviours or in none of their behaviours. For example, Wilson and Herrnstein ( ) describe a theory of criminal behaviour which describes people who commit crime as being impulsive. This implies that if a person could be taught to gain money in ways more approved by society than fraud for example, then this increase in self control would flow on to reduce the person's convictions for other kinds of crime. However, crime often provides larger rewards and the risks, such as imprisonment, occur with variable probabilities, making it difficult to teach people not to break the law. But, disregarding the problems in teaching this behaviour, research suggests that self control does not easily generalize to a wide range of behaviours and situations. The behavioural repertoire which makes up criminal behaviour is probably too diverse for widespread generalisation to occur.

Self control which has previously been learned in a fading procedure has been shown to generalize across time and to other schedules of reinforcement. Logue and Mazur (1981) demonstrated generalization across time. Three of the pigeons which participated in a fading procedure in Mazur and Logue's (1978) study were given a choice 11 months later between 2s ofgrain access immediately or 6s of grain delayed by 6s. This study found no difference in large reinforcer choices between the 1981 trial and the last condition from Mazur and Logue (1978).

However, in both of these choice situations a system of overhead lighting was used whereby an overhead light, corresponding to the colour of the key pecked, came on during delay and reinforcement periods. In a third condition of Logue and Mazur (1981), these overhead lights wer removed and the mean number of large reinforcer choices dropped from 19.5 to 7.2, and the number of large reinforcer choices only recovered for one bird when the lights were reinstated. So, generalization across time occurred, but the increase in self control was very situation specific.

Logue et al (1984) demonstrated that an increase in self control will carry over to another reinforcer schedule. In Experiment 1, a fading procedure was carried out. In Experiment 2, three of the birds which experienced the fading procedure in Experiment 1, were introduced into a concurrent VI30s VI30s schedule. The increase in Sa/Sd ratios which was achieved in Experiment1 continued in Experiment 2. In other words, in Experiment 2, the subject continued to be relatively more sensitive to amount ratios than to delay ratios when compared to non-fading exxposed subjects. So generalisation to another schedule can occur.

In the real world, self control involves nnore than choosing between large delayed and small immediate reinforcers. People also choose between alternatives which differ in the amount of effort associated with each and also choose between alternatives involving punishment. Self conttrol involving effort can be seen as choosing to do a harder task for a larger reward instead of an easy task for a small reard. Research has shown that the generalization of learned effort depends on the similarity of the effort training and transfer situation.

Eisenberger and Adornetto (1984) addressed the question of whether self control involving effort generalizes to self control involving delay. The training procedure involved 2 levels of effort crossed with absence or presence of a subsequent delay. At baseline, rewarded high effort led to greater self control involving effort than rewarded low effort, but had no effect on self control involving delay, and experiencing delayed reward did not increase self control involving effort.

The Present Study

Experiment 1 attempted to replicate a fading procedure using a single concurrent chain schedule and performing fewer sessions per each delay step. The justification for reducing the number of sessions at each step came from a comparison of the experimental and control groups in

Logue and Mazur (1984). The control group in that study experienced only 3 sessions of each delay step and showed evidence of increased self control until a reversal condition where the contingencies associated with each of the two keys were swapped over.

In the current experiment subjects performed 5 sessions at each fading level. As can be seen in Figure ?, only 1 bird increased large reinforcer choices when the first baseline (small delay =0.2s) and the final fading step are compared, and this difference is not large. However, the pattern of responding during the fading procedure was similar to that typically found (e.g. Mazur and Logue 1978). This pattern of response involves a large initial decrease in small reinforcer choices, followed by a plateau, then a rise of small reinforcer choices as the delay to the small reinforcers nears zero.

Experiment 2 examined a number of factors which may have caused the subjects in Experiment 2 to be nore self controlled than would be normally expected. The purpose of trying to increase baseline small reinforcer choices was to allow a fading procedure to be carried out in one of 2 concurrent chains which alternated in a multiple schedule, in Experiment 3.

The factors which Experiment 2 examined include the effects of food deprivation, length of the change-over delay and the presence of houselights signalling either the large or small reinfoecer. Preference in Experiment 2 was measured by an Impulsiveness measure which is equal to the difference between log ratios in Components 1 and 2. Where both components involve a choice between small immediate and large delayed reinforcers, then a high impulsiveness score indicates large preferences for the small reinforcer. In Experiment 2, the only conditions which had any significant effect on Impulsiveness values, were running each component separately and increasing food depriavation. An increase in Impulsiveness following increased food deprivation is predicted by Eisenberger et al (1982) and Snyderman (1983).

In Experiment 3 two concurrent chains alternated in a multiple schedule. One of these concurrent chains was always a choice between a smaller earlier reinforcer and a larger later reinforcer. In the remaining concurrent chain however, a fading procedure was carried out. The aim of this procedure was to discover whether the self control learned in the fading component would generalize to the non-fading component.

Unfortunately, only one bird showed any increase in self control in the fading procedure and this was slight, so the generalization question could not be addressed. However, the one bird which did increase large reinforcer choices in the fading procedure, was also the only bird to show a pattern of responding similar to that found by Mazur and Logue (1978).

Perhaps the multiple concurrent chain was too confusing for the birds. This idea is supported by the finding in Experiment 2 that running each component separately increased small reinforcer choices and that in Experiment 1, where only a single concurrent chain was run, all the subjects showed the typical response pattern mentioned earlier.

The learning of self control is central to many of society's aims, such as overcoming addictions and the prevention of crime. Various procedures have been developed which increase self control. These include commitment, manipulation of the relative amounts and delays, experiencing long delays, decreasing deprivation and fading procedures. It has not been established whether increasing self control in one behaviour or situation will lead to increased self control in another behaviour or situation. However, it does seem that there are different types of self control which do not generalise to each other. For example, self control involving effort does not generalise to self control involving delay. Also the generalisation of self control involving effort depends on the similarity between the learning and test situations (Eisenberger et al, 1984). Rachlin (1974) gives an example of self control where a person chooses between going to a dentist now with a little pain or later with a lot. Mischel and Grusec (1967) provide evidence that self control involving punishment is different from self control involving delay.

Mischel and Grusec (1967) asked children to choose between immediate small or delayed larger rewards and punishments. The large outcome delay was held constant for half the children while the probability of receiving the later outcome varied from 0.1 to 1.0. For the rest of the subjects, probability was constant but the delay to the large, later outcomes was varied between 1 day and 1 month. The results of this study are interesting as increasing the probability of the larger later outcome led to more choices of the delayed reward and more choices of the immediate punishment. However, increasing the delay to the large outcome increased the number of delayed reward choices but had no effect on punishment choices. In other words, the children were insensitive to delay when choosing between a small immediate or a large later punishment. This suggests that self control involving rewards may be different to self control involving punishment. So, Rachlin's dentist example can not be taken too generally as an example of self control.

If self control only generalises to very similar situations then describing a population as being generally lacking in self control is not accurate. Criminal populations have been described as lacking self control, but the range of behaviours which are described as criminal are so diverse that increasing self control would be an enormous task.

Self control theory can be applied to clinical situations. For example, eating disorders can be looked at in terms of choices between rewards differing in amount and delay. When people choose between rewards delayed by an equal time, the largest reward is chosen. Conversely, when choosing between delays of equal size, the most immmediate reinforcer is chosen, as reinforcers lose their effectiveness the further away in time they are.

However, the situation becomes more complicated when a person has to choose between a small immediate and a larger more delayed reinforcer. If choosing in advance of both reinforcers, the large reinforce is chosen. But as the small reinforcer becomes closer in time, it becomes more effective and so the person changes their choice to the smaller immediate reinforcer. Applications of self control theory to obesity have often concentrated on ways of making the small reinforcer either unavailable, (by choosing the large reinforcer in advance and removing the small reinforcer) or unattractive. Examples of these strategies include removal of problem foods from the house and storage of food in a frozen state (McReynolds, Green and Fisher, 1983). Attending a health farm is a classic commitment strategy as the impulsive alternatives are just not available.

Dieting is further complicated by the findings of Eisenberger et al (1982) which indicate that food deprivation increases impulsiveness for food reinforcers. So, the more you diet, the more you will want to eat.

Each time a remote reward is experienced, the behaviour which leads to that reward is strengthened and so remote consequences start to control behaviour. This is important as many remote rewards are never experienced, after all, it takes a long time to lose sustantial amounts of weight, and a lot of attempts to quit smoking, for example.

Fading procedures increase large reinforcer choices by changing the relationship between reward effectiveness and time before reward. A person's sensitivity to delay decreases in a fading procedure (Logue et al 1984) so that the larger reward is preferred both in advance of the two reinforcers and also when the small reinforcer is available immediately. So, for example, in the morning a healthy lunch is preferred and made and at lunchtime it actually gets eaten in preference to something more calorific which would previously have been preferred.

It is unclear how general the self control which has been learned through these procedures is. Self control has been described as a general trait so that an overeater would probably be impulsive in other areas of their lives. The current experiment was designed to discover whether learning self control in one situation would affect a self control choice in a similar situation. Unfortuantely, the current experiment did not answer the question. However, the research into generalization mentioned earlier, suggests that self control is not a general thing at all. There appears to be different types of self control which do not generalize to each other, and when generalization does occur, it has only been to similar situations.

The impications of this are important. If a person is impulsive in several different behaviours, then training would have to occur in each situation. The application of this self control research to criminal behaviour has been overly simplified as the behaviours which are illegal are very wide. As self control is not as general as assumed, it is reasonable to expect that a person could be impulsive in one area but not in another. For example, a person who converts cars does not necessarily commit sexual abuse.

Perhaps in future research it is important to find the limits of generalization and to find ways of increasing generalization, so that training in self control can be more effective. After all, being self-controlled at work when dieting is of little benefit if at home the person is extremely impulsive. If more effective ways of increasing self control can be found, and ways of making these behaviour changes more general can be researched, then a lot of people could experience an increased quality of life.

CHAPTER SIX

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